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ESSAYS OF A NATURALIST

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A SELECTION FROM THE WORKS OF

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WITH 26 ILLUSTRATIONS

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EDITOR'S NOTE

THE aim of this series is to reproduce some of the best contemporary and recent literature in a form and at a price suitable for educational purposes.

The Editor presents this selection of articles from the pen of one of our most distinguished naturalists in the confidence that they possess as much intrinsic interest for younger readers as they have held for an older audience, and that they will afford an admirable general introduction to the subject-matter and methods of natural science, and the study of scientific literature.

The books from which the articles are taken are indicated in the *Contents*. All are published by Methuen & Co., Ltd.

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CONTENTS

[1] From *Science from an Easy Chair*. First Series.
[2] From *Science from an Easy Chair*. Second Series.
[3] From *Great and Small Things*.
[4] From *Diversions of a Naturalist*.
[5] From *Secrets of Earth and Sea*.

ESSAYS OF A NATURALIST

THE DRAGON: A FANCY OR A FACT

I AM about to write of loathly dragons, "gorgons and hydras and chimæras dire." Every one knows what a dragon looks like, though probably most people could not give a minute description of the beast. A number of quite distinct creatures, some living on land, some in sea, are spoken of in the Bible by a word which is translated as "dragon." The ancient Welsh chieftains, like many fighting princes of old days, bore a "dragon" on their banners, and were themselves called "dragons" (Pen-dragon), and when a knight slew such a chieftain fabulous stories grew up as to his combat with and slaughter of a "dragon."

The complete, legitimate dragon of the present day is the dragon of heraldry, which is maintained in proper form and with authorized attributes by the Heralds' College. I have a drawing of this "official" beast before me (Fig. 1). He is represented as of large size, but whether theoretically the heralds of to-day consider him to be as large as a lion or ten times as long and tall I do not know. His body is lizard-like, and covered with scales resembling those of some lizards (unlike a crocodile in this respect). His head is not unlike that of a crocodile, excepting that he has a short, sharp horn on his nose, and a beard on his chin, and also a pair of large pointed ears which no living reptile possesses. His mouth is open, showing teeth like those of a crocodile, and from it issues a remarkable tongue, terminating in an arrow-head-shaped weapon (presumably

a "sting") unlike anything known in any living animal. His tail is very long and snake-like (an important fact when we come to consider his ancestry), and is thrown into coils. It terminates in an arrow-head-shaped structure like that of the tongue, quite unlike anything known in any real animal. He has four powerful limbs, which are not like

FIG. 1.—The heraldic dragon: observe the bat-like wings, the ears, the horned nose, the beard, the arrow-like tongue and tail-piece, the scaly body, the dorsal crest, the snake-like tail with its unnatural arrow-like termination.

FIG. 2.—The heraldic griffin. It alone of the dragon-like monsters has feathery wings.

those of a lizard or a crocodile. They resemble those of an eagle, and have grasping toes and claws, three directed forward and one backward. In addition, he has a pair of wings, which are leathery, and supported by several parallel bars, a structure which gives the wings a remote resemblance to those of a bat. The wing is quite unlike that of a pterodactyle (the great extinct flying lizard), and has no resemblance whatever to that of a bird, which is, of course, formed by separate quill feathers set in a row on the bones of the fore-arm and hand. The wings are always represented (even in illegitimate and Oriental dragons) as much too small to carry the dragon in flight. The dragon has, further, a crest of separate triangular plates set in a row along the mid-line of his back, extending from his head to the end of his tail. Some lizards (but not crocodiles) have such a crest. The most like it is that of the New Zealand lizard, called the *Sphenodon*.

Such is the creature called "the" dragon. But heraldry recognizes some other terrible beasts allied to the dragon; in fact, what zoologists would call "allied species." The griffin, for instance (Fig. 2), is a four-legged beast like the dragon, but has the beak and wings and fore-feet of an eagle, and the hind-legs and tail of a lion. The heraldic

Fig. 3.—Hercules destroying the hydra (copied from an ancient Greek vase).

Fig. 4.—The heraldic wyvern.

hydra is a dragon, such as I have above described, but with seven heads and necks. The ancient Greek representation of the hydra destroyed by Hercules (as painted on vases) was, on the contrary, based upon the octopus, or eight-armed cuttle-fish, each arm carrying a snake-like head (Fig. 3). The wyvern is an important variety of the dragon tribe, well known to heralds, but not to be seen every day. It so far conforms to natural laws that it has only two legs, the fore-limbs being the wings (Fig. 4). The true dragon and the griffin, like the angel of ecclesiastical art, have actually six limbs—namely, a pair of fore-legs or arms, a pair of hind-legs, and, in addition, a pair of wings. Occasionally an artist (even in ancient Egyptian works of art) has attempted to avoid this redundance of limbs by representing an angel as having the arms themselves provided with an expanse of quill feathers. This is certainly a less extraordinary arrangement than the outgrowth of wings (which in birds, bats, and pterodactyles

actually are the modified arms or fore-limbs), as an extra pair of limbs rooted in the back. The wyvern and the cockatrice and the basilisk (Fig. 5) (which, like the Gorgon Medusa, can strike a man dead by the mere glance of the eye) are remarkable for conforming to the invariable vertebrate standard of no more than two pairs of limbs, whether legs, wings, or fins. The name " lind-worm " is given to a wyvern without wings (hence the Linton Worm and the Laidley Worm of Lambton), and appears in various heraldic devices and in legendary art; whilst in the arms of the Visconti of Milan we climb down to a quite simple serpent-like creature without legs or wings, known as the " guivre."

Without looking further into the strange and fantastic catalogue of imaginary monsters, one must recognize that it is a matter of great interest to trace the origin of these marvellous creations of human fancy, and the way in which they have first of all been brought into pictorial existence, and then variously modified and finally stereotyped and maintained by tradition and art. It has not infrequently been suggested, since geologists made us acquainted with the bones of huge and strange-looking fossil reptiles dug from ancient rocks, that the tradition of " the dragon " is really a survival of the actual knowledge and experience of these extinct monsters on the part of " long-ago races of men." It is a curious fact, mentioned by a well-known writer, Mrs. Jameson, that the bones of a great fossil reptile were preserved and exhibited at Aix in France as the bones of the dragon slain by St. Michael, just as the bones of a whale are shown as those of the mythical Dun-cow of Warwick in that city.

There are three very good reasons for not entertaining the suggestion that the tradition of the dragon and similar beasts is due to human co-existence with the great reptiles of the past. The first is that the age of the rocks known as cretaceous and jurassic (or oölitic), in which are found the more or less complete skeletons of the great saurians —many bigger in the body than elephants, and with huge

tails in addition, iguanodon, megalosaurus, diplodocus, as well as the winged pterodactyles and a vast series of such creatures—is so enormously remote that not only man but all the hairy warm-blooded animals like him, did not come into existence until many millions of years after these rocks had been deposited by water and the great reptiles buried

FIG. 5.—The heraldic basilisk, also called the Amphysian Cockatrice. Observe the second head at the end of its tail—a feature due to perversion of the observation that there are some snake-like creatures (Amphisbena) with so simple a head that it is at first sight difficult to say which end of the creature is the head and which is the tail.

in them had become extinct. The cave-men of the Pleistocene period are modern, even close to us, as compared with the age when the great saurians flourished. That was just before the time when our chalk-cliffs were being formed as a slowly growing sediment on the floor of a deep sea. No accurate measure of the time which has elapsed since then is possible, but we find that about 200 feet thickness of deposit has been accumulated since the date of the earliest human remains known to us—whilst over 5,000 feet have accumulated since the chalk began to be deposited, and the great saurians ceased to exist. If we reckon, in accordance with the most moderate estimate, a quarter of a million years for the upper 200 feet of deposit or human period (Pleistocene), we must suppose that twenty or thirty times as long a period has elapsed to allow time for the deposit of the 5,000 feet of sand and rock since the great saurians ceased to exist. This would be some six or seven million years—a long while for tradition to run, even supposing man existed all that time, which he did not. And the probability is that this estimate of the time is far too small: a hundred million years is nearer the truth.

Suppose that man came into existence as an intelligent

creature, capable of handing on a tradition, as much as half a million or even a million years before the date of the remains of the earliest cave-men discovered in Europe, we yet get no long way down the avenue of past time. Man would still be separated by millions of years and long ages of change and development of the forms of animal life on the earth's surface, from the period of the great reptiles or saurians who flourished before the chalk was deposited. And there is good evidence that none of those great saurians survived the date of the chalk. They died out and their place was taken by the earliest ancestors of elephants, rhinoceroses, horses, cattle, lions, and monkeys, from which in the course of ages the animals we know by those names were developed, whilst very late in the history man was produced. The reptiles continued as small, furtive creatures—the lizards and a few biggish snakes and crocodiles—but no descendants of " the great Dinosaurs " survived.

Another reason against the supposed survival of a real tradition of dragons is that, even in regard to much later —immensely later—creatures, such as the mammoth or hairy elephant, which we know was contemporary with man, there is no real tradition. The natives of the sub-arctic regions in which the skeletons and whole carcasses of the mammoth are found in a frozen state, and from whence many hundreds of tusks of the mammoth have been since the earliest times yearly exported and used in Europe as ivory, have no " tradition " of these creatures. They have fanciful stories about the ghosts of the mammoths, but they call their tusks " horns," and have no legends of the monster as a living thing. The use of mammoth's ivory in Northern Europe dates back for a thousand years historically, and probably has never ceased since the days of the cave-men. Three years ago I examined the richly carved drinking horn of a Scandinavian hero, dating from the tenth century, and preserved amongst the treasures of York Minster, and I have little doubt that it is fashioned from the tusk of a mammoth.

A third reason for rejecting any connection of the dragon with a real reminiscence of the great extinct saurians is that its origin and the gradual building up in human fancy can be traced in the same way as that of many other fanciful and legendary creatures by reference to the regular operation of the imagination in successive ages of mankind.

FIG. 6.—The Chinese Imperial Dragon, from a drawing on a tile of the old Imperial Palace of Nankin. It has five claws. No one outside the Imperial service may use it, under penalty of death. Ordinary people have to be content with a four-clawed dragon. Compare this with the European heraldic dragon, Fig. 1.

All races of men have imagined monsters by combining into one several parts of different animals. The centaur of the Greeks is a blend of man and horse, the great "divine" chimera of the Greeks was a two-headed blend of lion and goat, and any such mixed creature is technically called nowadays "a chimera." The dragon is classed by heralds as a chimera. Sometimes one of these imaginary beasts has its origin in a terrible or weird animal, which really exists in some distant land, and is celebrated or even worshipped by the inhabitants of that distant land, whose descriptions of it are carried in a distorted and exaggerated form to regions where it does not exist.

The dragon appears to be nothing more nor less in its origin than one of the great snakes (pythons), often 25 feet in length, which inhabit tropical India and Africa. Its dangerous character and terrible appearance and movement impressed primitive mankind, and traditions of it have passed with migrating races both to the East and to the West, so that we find the mythical dragon in ancient China and in Japan, no less than in Egypt and in Greece. It retains its snake-like body and tail, especially in the Chinese and Japanese representations (Figs. 6 and 7); but in both East and West, legs and wings have been gradually added to it for the purpose of making it more terrible and

expressing some of its direful qualities. Chinese traditions indicate the mountains of Central Asia as the home of the dragon, whilst the ancient Greeks considered it to have come from the East. As a matter of fact, the Greek word "drakon" actually meant plainly and simply a large snake, and is so used by Aristotle and other writers. There

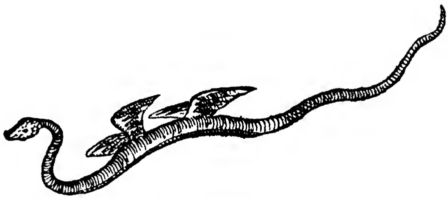


FIG. 7.—A flying snake with two pairs of wings—a "fabulous" creature thus drawn in an ancient Chinese work, the *Shan Hai King*. This book dates from about A.D. 350, but probably is based on records of a thousand years' earlier date.

is a beautiful Greek vase-painting showing the dragon which guarded the golden apples of the Hesperides as nothing more than a gigantic snake (without legs or wings), coiled round the trunk of the tree on which the apples are growing (like the later pictures of the serpent on the apple tree in the Garden of Eden), whilst the ladylike Hesperides are politely welcoming the robust Hercules to their garden.

The worship and propitiation of the serpent is an immensely old form of religion (antecedent to Judaism), and exists, or has existed, in both the old world and the new. The Egyptians revered a great serpent-god called "Ha-her," or "great Lord of fear and terror"; to him the wicked were handed over after death to be bitten and tortured. The evil spirit in the Scandinavian mythology was a huge snake—and the connection, not to say confusion, of the terrible snake with the dragon on the part of the early Christian is shown by the words in Revelation xx. 1, 2, "the dragon, that old serpent, which is the Devil and Satan." The mediaeval devil with goat's feet retained the dragon's tail with its curious triangular termination.

To the Greeks and Romans snakes were not such very

terrible creatures, since the kinds found in South Europe are small and harmless—only the viper being poisonous—and they regarded the serpent as a beneficent creature, the familiar of Esculapius the god of medicine, companion of the household gods (the Lares), and guardian of sacred places, tombs, and concealed treasure (Fig. 11). The

FIG. 8.—A votive tablet (ancient Rome) showing what is meant for a snake, but has been "improved" by the addition of fins like those of the eel.

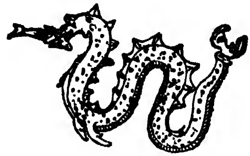


FIG. 9.—Ancient Roman painting of a so-called marine serpent—really an eel-like fish—inaccurately represented. The fins show how, from such pictures, the belief in winged serpents might take its origin.

snake was the special earth-god, subterranean in habit, cunning, subtle, and gifted with powers of divination. The conception of the serpent as an avenging monster kept continually thrusting itself from the East into the popular mythology of the Greeks, and finally led to the building up of the dragon as a winged and clawed creature distinct from the harmless but cunning snake familiar to them. Even in India there arose a sort of double attitude towards the snake (as is not uncommon in regard to deities). On the one hand he was regarded as all that was terrible, destructive, and evil, and on the other as amiable, kindly, and wise. The services of the beautiful rat-snake in destroying house rats rendered him and his kind welcome and valued guests. In Egypt we find representations of small winged snakes without legs, and the ancient traveller, Herodotus, believed that they represented real creatures, as did the Roman naturalist, Pliny. Very probably the belief in winged snakes is due to the similarity of the snake and the eel in general form, since the paired fins of the eel

close to the head (see Figs. 8 and 9) correspond in position with the wings shown in the Egyptian drawings of winged serpents. The particular form of winged snake pictured on Egyptian monuments (see Figs. 10, 11) appears to me to be a realization of stories and fancies based on real experience of the locust. It was the terrible and destruc-

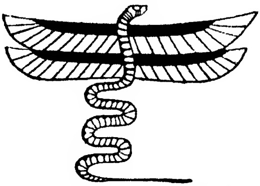


FIG. 10.—Egyptian four-winged serpent—as drawn on ancient Egyptian temples.

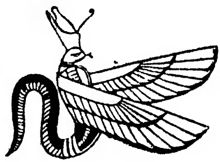


FIG. 11.—Two-winged serpent, symbolic of the goddess Eileithya, from a drawing on an Egyptian temple.

tive locust of which Herodotus tells—calling it " a winged serpent." The Egyptian pictures of winged serpents have wings resembling those of an insect (see Figs. 10 and 11), and sometimes they are represented with one and sometimes with two pairs.

Aristotle says that, as a matter of common report in his time, there were winged serpents in Africa. Herodotus, on the contrary, says there were none except in Arabia, and he went across the Red Sea from the city of Bats in order to see them. He did not, however, succeed in doing so, though he says he saw their dead bodies and bones. He says that they hang about the trees in vast numbers, are of small size and varied colour, and that they are kept in check by the bird known as the Ibis, which on that account is held sacred, since they increase so rapidly that unless devoured they would render it impossible for man to maintain himself on the earth. They invade Egypt in swarms, flying across the Red Sea. All this agrees with my suggestion that the winged "serpents" heard of by Herodotus were really locusts; and the creature drawn in Fig. 11 may well be a locust transformed by fancy into a winged snake.

It would be a very interesting but a lengthy task to trace out the origin and history of the various traditional monsters, such as the basilisk, the gorgon, the cockatrice, the salamander, and the epimacus, which have come into European legend and belief, and to give some account of the special deadly qualities of each. St. Michael and St. George slaughtering each his dragon and rescuing a lovely maiden from its clutches are only appropriations by the new religion of the similar deeds ascribed to Greek heroes, such as Hercules, Bellerophon, and Perseus. Often a belief in the existence of a monster has arisen by a misunderstanding, on the part of a credulous people, of a drawing or carving showing a strange mixture of the leading characteristics of different animals, which was meant by the man who made it to be only symbolic of a combination of qualities. Just as the Latins and mediaeval people credulously accepted Greek symbolic monsters as real, and transmuted Greek heroes into Christian saints, so were the Greeks themselves deluded by strange carvings and blood-curdling legends which reached them at various dates from mysterious Asia into a belief in the actual existence of a variety of fantastic monsters. "The Greeks," says M. E. Pottier, a distinguished French writer on Greek mythology, "often copied Oriental representations without understanding them." The conventional dragon probably came from Indian sources through Persia to China, on the one hand, spreading eastwards, and to the Latins of the early Roman Empire, on the other hand, spreading westwards; but at what date exactly it is difficult to make out.

In mediaeval, as well as in earlier times, marvellous beasts were brought into imaginary existence by the somewhat unscrupulous enterprise of an artist in giving pictorial expression to the actual words by which some traveller described a strange beast seen by him in a foreign land. Thus the "unicorn," which was really the rhinoceros, was seen by travellers in the earliest times, and was described as an animal like a horse, but with a single

horn growing from its forehead. The heraldic draughtsman accordingly takes the spirally twisted narwhal's tusk, brought from the northern seas by adventurous mariners (the narwhal being called "the unicorn fish") as his unicorn's horn, and plants it on the forehead of a horse, and says, "Behold! the unicorn." Meanwhile the real "unicorn," the rhinoceros, became properly known as navigation and Eastern travel extended, and true unicorns' horns, the horns of the rhinoceros, richly carved and made into drinking cups, not at all like the narwhal's tusk, were brought to Europe from India. One was sent to Charles II by "the Great Sophy," and handed over to the Royal Society by the King for experiment. These horns were asserted to be the most powerful antidote or destroyer of poison, and a test for the presence of poison in drink. There was no truth whatever in the assertion, as the Royal Society at once showed. Yet they were valued at enormous prices, and pieces were sold for their weight in gold. A German traveller in the time of Queen Elizabeth saw one which was kept among the Queen's jewels at Windsor, and was valued, according to this writer, at £10,000.

Credulity, fancy, and hasty judgment are accountable for the belief in mythical and legendary monsters. Yet they have great interest for the scientific study of the growth of human thought and of the relationships of the races of mankind. They are often presented to us in beautiful stories, carvings, or pictures, having a childlike sincerity and a concealed symbolism which give to the wondrous creatures charm and human value.

THE GREAT GREY SEAL

IT is always pleasing to find that intelligent care can be brought to bear on the preservation of the rare and interesting animals which still inhabit parts of these British Islands, though it is not often that such care is actually exercised. Mr. Lyell (a nephew of the great geologist Sir Charles Lycll) in April 1914 introduced a Bill into the House of Commons which is called the Grey Seals (Protection) Bill. It came on for consideration before the Standing Committee, was ordered to be reported to the House without amendment, and has now passed into law.

The Great Grey Seal is a much bigger animal than the Common Seal, the two species being the only seals which can be properly called "British" at the present day, though occasionally the Harp Seal, or Greenland Seal, and the Bladder-nosed Seal are seen in British waters, and may emerge from those waters on to rocky shores or lonely sandbanks. The Great Grey Seal is called "Halichœrus grypus" by zoologists, whilst the Common Seal is known as "Phoca vitulina." The male of the former species grows to be as much as 10 feet in length, whilst that of the Common Seal rarely attains 5 feet. Both these seals breed on the British coast. The Common Seal frequents the north circumpolar region, being found on the northern coasts on both sides of the Atlantic, and also on both sides of the Pacific, and even makes its way down the coasts of France and Spain into the Mediterranean, where it is rare. A few years ago one appeared on the beach at Brighton! It may often be seen on the west coast of Scotland, of Ireland, Wales, and Cornwall, where it breeds in caves. Its hairy coat is silky, and has a yellowish-grey tint spotted with black and dark grey, most abundantly on the back.

The Great Grey Seal does not occur in the Pacific, but is limited to the northern shores on both sides of the Atlantic.

Its coat is of a more uniform greyish-brown colour than that of the Common Seal, and when dried by exposure to the sun has a silvery-grey sheen. The Great Grey Seal is a good deal rarer on our coasts than is the Common Seal. It is now limited to the south, west, and north coasts of Ireland, to the great islands on the West of Scotland, the Orkneys, the Shetlands, and some spots on the east coast of Scotland. It is heard of as a rare visitor to the Lincolnshire "Wash," the coasts of Norfolk, Cornwall, and Wales. Some years ago I found a newly-born Grey Seal on the shore of Pentargon Cove, near Boscastle, North Cornwall. It appears that whilst (contrary to the statements of some writers) the Common Seal produces its young most usually in caves or rock-shelters, the Great Grey Seal chooses a remote sand island or deserted piece of open shore for its nursery. The Common Seal gives birth to its young—a single one or a pair—in June; the Great Grey Seal about the 1st of September. While the young in both species is clothed when born in a coat of long yellowish-white hair, this coat is shed in the case of the Common Seal within twenty-four hours of birth, exposing the short hair, forming a smooth, silky coat, as in the adult, and the young at once takes to the water and swims. On the other hand, the long yellowish-white coat of hair persists in the young of the Great Grey Seal for six or seven weeks, during which time it remains on shore, and refuses to enter the water. It is visited at sundown by the mother for the purpose of suckling it. According to Mr. Lyell, this renders the young of the Great Grey Seal peculiarly liable to attack by reckless destructive humanity, and he accordingly proposes legislation to render it a penal offence to destroy the young seals or the mothers during the nursing season. It is estimated that the total number of Great Grey Seals in Scottish waters has been reduced to less than 500, and that in English and Irish waters the total is even less.

It has often been desired by naturalists that a check should be put by the Legislature upon the wanton destruction of the common seal, as well as of the grey seal. It is

certainly a regrettable result of the increased visitation of our remote rocky shores by holiday-makers, so-called "sportsmen" and thoughtless ruffians of all kinds, that the large, and perfectly harmless, grey seal is likely to be exterminated. In former times in these islands, as to-day in more northern regions, there was a regular "seal fishery," and vast numbers of seals were annually slaughtered for the sake of their skins and fat. The fur of both our native species, though differing vastly from the soft under-fur of the fur-seals, or Otariæ, of the North Pacific—which belong to a different section of the seal group, having small external "ears," and hind feet which can be moved forward and used in walking—is yet largely used for making gloves and thick overcoats. To-day the number of British seals killed and brought to market is so small that no local fishery interests would suffer were all protected by the law during the spring and summer, when breeding and the rearing of the young is in progress. There is even less reason for objecting to the protection of the larger and rarer Great Grey Seal, which, unless it had been placed under the shelter of an Act of Parliament, would in five or six years have ceased to be a denizen of the British Islands.

Owing to my having accidentally made the acquaintance of a young grey seal, as mentioned above, in North Cornwall, I feel a special interest in the legislative protection of this kind. I was at Boscastle at the end of August, and was delighted to see there on the morning after my arrival three or four of the common seal swimming in the little rock-bound harbour. I was told by native authorities that there was a cave in the rocks at the side of Pentargon Cove, a couple of miles distant (formerly inaccessible from the cliffs), where these seals breed, and that it had been the custom of some of the young men of the district to go round there in a boat when wind and tide served in the early spring and "raid" the cave. They could get in at low tide, and, armed with heavy cudgels, they would attack the seals which were congregated in the cavern to the number of thirty or forty. A single well-delivered

blow on the nose was sufficient, I was assured, to kill a full-grown seal, and if fortunate the raiders might secure ten or a dozen seals, which were then sold for their skins and oil to Bristol dealers. The enterprise was dangerous on account of the rising tide and the struggles of the seals and their assailants among the slippery rocks and deep pools in the darkness of the cave. Cruel and savage as the adventure was, it yet had its justification on a commercial basis—similar to that claimed for other "fisheries" of the great beasts of the sea hunted by man for their oil and skins. The seals of this cave were undoubtedly the small common seal—the Phoca vitulina—and I gathered that little had been heard of late years of successful expeditions to these rocks. I was, however, told that a path had been cut and ropes fastened to iron stanchions in the face of the rocky cliffs of Pentargon Cove just before my visit to Boscastle, which rendered it now comparatively easy to descend the 150 feet of rock from the hill overlooking it and reach the shore of the curiously isolated and enclosed cove.

So, with two companions—my sisters—I set off the next morning for Pentargon Cove. We climbed down the face of the cliff by the aid of the much-needed ropes and found ourselves on the shore, the tide being low. We hoped that we should be able to get a view of the "seal-cave" and some of its inhabitants swimming in its neighbourhood. We were disappointed in this, and my companions hastened down to the water's edge, in order to get as near as possible to the rocky sides of the cove. I was about to follow them when I saw, lying in the open, on the pebbles above high-tide mark, what I took at first for a white fur cloak left there by some previous visitor. I walked up to it, when, to my extreme astonishment, it turned round and displayed to my incredulous gaze a pair of very large black eyes and a threatening array of teeth, from which a defiant hiss was aimed at me. It was a baby seal, covered all over with a splendid growth of white fur, three inches deep. He was twice as big as the fur-covered young of the common seal —more than two feet long—his black eyes were as big as

pennies, and he was lying there on the upper beach, far from the water, in the full blaze of the sun, as dry and as "fluffy" as a well-dressed robe of Polar bear's skin. We were indeed well rewarded for our excursion in search of the seal's cave of Pentargon Cove! For this was a new-born pup of the Great Grey Seal, entirely unconnected with the inferior population of the inaccessible cave, laid here in the open by his mother at birth (as is the habit of her species), little suspecting that the long-secluded shore of Pentargon Cove had that year been rendered accessible to marauding land-beasts for the first time. Not knowing the peculiarities of the grey seal and the refusal of its young to enter the water until six weeks after birth, when it sheds its coat of long white hair, we cautiously rolled the little seal on to my outspread coat and carried him to the water's edge. After the hissing with which he had greeted my first approach he was not unfriendly or alarmed, and for my part I must say that I have never yet stumbled upon any free gift of Nature which excited my admiration and regard in an equal degree. His eyes were beautiful beyond compare. We placed him close to the water and expected him to wriggle into it and swim off, but, on the contrary, he wriggled in the opposite direction, and slowly made his way, by successive heaves, up the beach. He was not more than a day or two old, as was shown by the unshrunken condition of the umbilical cord. We did not like to leave him exposed to the attacks of vagrant boys, who might climb down into the cove, so we carried him on my coat to the shelter of some large rocks, a hundred yards along the shore. There, with much regret, we left him.

But on the following evening, as we sat down to dinner, I heard from some other visitors at the Wellington Inn, to whom, under pledge of secrecy, I had confided our discovery, that they had been to Pentargon Cove to visit our young friend, and found that he had been removed (probably by his mother) back to the exact spot where we had found him. They also stated that his presence there had become known in the village, and that the conviction had been

expressed that "the boys" would certainly go and stone him to death! I had already reproached myself for going elsewhere that day instead of to Pentargon Cove to look after my young seal, and now I hastily left my dinner, procured in the village two men and a potato sack, and hurried to Pentargon Cove. As we approached the edge of the cliff the sun was setting, and the cove was very still and suffused with a red glow. Then a weird sound rent the air, like that made by one in the agonies of sea-sickness. It was the little seal calling for his mother! It is the habit of the females of this species to leave the shore during the day when they go in search of the fish on which they feed, and to return to their young in the evening, in order to suckle them. I could see, from above, my baby friend—a little white figure all alone in the deepening gloom of the great cliffs—raising his head and, by his cries, helplessly inviting his enemies to come and destroy him. In a few minutes we were down by his side, had placed him in the potato sack, and brought him to the upper air. On the way to the inn I purchased a large-sized baby's bottle with a fine india-rubber teat. We placed the little seal on straw in a large open packing-case in the stables, whilst the kitchen-maid warmed some milk and filled the feeding-bottle. Then I brought it to him, looking down on his broad, white-furred head, with its wonderful eyes, set so as to throw their appealing gaze upwards. I touched his nose with the milky india-rubber teat. With unerring precision his lips closed on it, his nostrils opened and shut in quick succession, and he had emptied the bottle. I gave him a quart of milk before leaving him and getting my own belated meal. He slept comfortably, but at four in the morning his cries rent the air, and threatened to wake every one in the hotel. I had to get up, descend to the kitchen, warm some more milk for him, and satisfy his hunger. He became fond of the bottle, and also of the friend who held it for him. I arranged to take him to the Zoological Gardens when, after three days, I left Boscastle. He travelled to London in the guard's van in a specially

constructed cage, and was as beautiful and happy as ever when I handed him over to the superintendent at Regent's Park.

In those days (as it happened) there was little understanding or care at "the Gardens" as to the feeding of an exceptional young animal like my little seal. It is possible to treat cow's milk so as to render it suitable to a young carnivore, much as it is "humanized" for the feeding of human babies, and I was willing to pay for a canine foster-mother were such procurable. I had then to leave London in order to preside over one of the sections of the British Association's meeting at Southport, and intended to take complete charge of my baby seal upon my return. But in less than a week the neglectful guardians at Regent's Park had killed him with stale cow's milk. I believe such a foundling would have a better chance there to-day, but the rearing of young mammals away from their mother is, of course, a difficult and uncertain job.

I do not regret having taken the baby seal from Pentargon Cove, for I undoubtedly saved him from a violent death, whilst his mother would soon recover from the loss due to my action—a loss to which she and her fellow "grey seal-mothers" must be not unfrequently exposed from other causes. I do regret, however, that it did not occur to me until too late that it would have been a wonderful experience to lie quietly on the shore some few yards from the baby seal, as the sun set, and then to see and hear the great seal-mother—7 or 8 feet long—swim into the cove, raise her gigantic bulk on the shore, and heave herself across the pebbles to her eager child. To witness the embraces, caresses, and endearments of the great mysterious beast would have been a revelation such as a naturalist values beyond measure. And so I hope, with all my heart, that Mr. Lyell will succeed in his good work of protecting the Great Grey Seal.

VESUVIUS IN ERUPTION

AT intervals of ten to twenty years the best-known volcano in the world—Vesuvius, on the Bay of Naples—has in the last two centuries burst into eruption, and the probability of the recurrence of this violent state of activity, at no distant date, renders some account of my own acquaintance with that great and wonderful thing seasonable. We inhabitants of the West of Europe have little personal experience of earthquakes, and still less of volcanoes, for there is not in the British Islands even an " extinct " volcanic cone to remind us of the terrible forces held down beneath our feet by the crust of the earth. In regions as near as the Auvergne of Central France and the Eiffel, close to the junction of the Moselle with the Rhine, there are complete volcanic craters whose fiery origin is recognized even by the local peasantry. They are, however, regarded by these optimist folk as the products of ancient fires long since burnt out. The natives have as little apprehension of a renewed activity of their volcanoes as we have of the outburst of molten lava and devastating clouds of ashes and poisonous vapour from the top of Primrose Hill. Nevertheless, the hot springs and gas issuing from fissures in the Auvergne show that the subterranean fires are not yet closed down, and may at any day burst again into violent activity.

Such also was the happy indifference with which from time immemorial the Greek colonists and other earlier and later inhabitants of the rich and beautiful shores of the Neapolitan bay before the fateful year A.D. 79, had regarded the low crater-topped mountain called Vesuvius or Vesbius, as well as the great circular forest-grown or lake-holding cups near Cumæ and the Cape Misenum, at the northern end of the bay—known to-day as the Solfatara, Astroni, Monti Grillo, Barbaro, and Cigliano—and the

lakes Lucrino, Averno, and Agnano. These together with the Monte Nuovo—which suddenly rose from the sea near Baiæ in 1538 and as suddenly disappeared—constitute " the Phlegræan fields." Vesuvius was loftier than any one of the Phlegræan craters, and the gentle slope by which it rose from the sea level to a height of nearly 3,700 ft. had, as now, a circumference of ten miles. It did not terminate in a " cone," as in later ages, but in a depressed, circular, forest-covered area measuring a mile across, which was the ancient crater. A drawing showing the shape of the mountain at this period is the work of the late Prof. Phillips of Oxford (Fig. 12). The soil formed around and upon the ancient lava-streams of Vesuvius appears to have been always especially fertile, so that flourishing towns and villages occupied its slopes, and the ports of Herculaneum, Pompeii, and Stabiæ were the seats of a busy and long-established population. The existence of active volcanoes at no great distance from Vesuvius was, however, well known to the ancient Greeks and Romans. The great Sicilian mountain, Etna—more than 10,000 ft. in height, rising from a base of ninety miles in circumference—and the Lipari Islands, such as Stromboli and Volcano, were for many centuries in intermittent activity before the first recorded eruption of Vesuvius—that of A.D. 79—and great eruptions are recorded as having occurred in the mountain mass of the island of Ischia, close to the Bay of Naples, in the fifth, third, and first centuries B.C.

Nevertheless, the outburst of Vesuvius in A.D. 79 and its re-entrance into a state of activity came upon the unfortunate population around it as an absolutely unexpected thing. At least a thousand years—probably several thousand years—had passed since Vesuvius had become " extinct." All tradition of its prehistoric activity had disappeared, though the learned Greek traveller Strabo had pointed out the indications it presented of having been once a seat of consuming fire. From A.D. 63 there were during sixteen years frequent earthquakes in its neighbourhood, which, as we know by records and inscriptions, caused

serious damage to the towns around it, and then suddenly, on the night of Aug. 24, A.D. 79, vast explosions burst from its summit. A huge black cloud of fine dust and cinders, lasting for three days, spread from it for twenty miles around, streams of boiling mud poured down its sides, and in a few hours covered the city of Herculaneum, whilst a

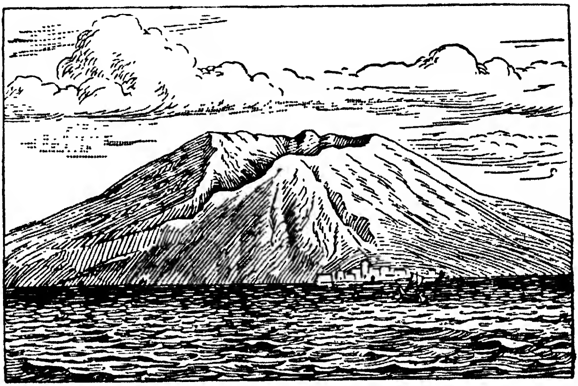


FIG. 12.—Vesuvius as it appeared before the eruption of August 24, A.D. 79. From a sketch by Prof. Phillips, F.R.S.

dense shower of hot volcanic dust completely buried the gay little seaside resort known as Pompeii. Many thousand persons perished, choked by the vapours or overwhelmed by the hot cinders or engulfed in the boiling mud.

The great naturalist Pliny was in command of the fleet at Cape Misenum, and went by ship across the bay to render assistance to the inhabitants of the towns at the foot of Vesuvius. Pliny's nephew wrote two letters to the historian Tacitus, giving an account of these events and of the remarkable courage and coolness of his uncle, who, after sleeping the night at Stabiæ, was suffocated by the sulphurous vapours as he advanced into the open country near the volcano. The friends who were with him left him to his fate and made their escape. The younger Pliny had prudently remained, out of danger, with his mother at Misenum.

The alternating periods of activity and of rest exhibited by volcanoes seem to us capricious, and even at the present day are not sufficiently well understood to enable us to discern any order or regularity in their succession. Vesuvius is a thousand centuries old, and we have only known it for thirty. We cannot expect to get the time-table of its activities on so brief an acquaintance. Strangely enough, Vesuvius, having, after immemorial silence, spasmodically burst into eruption and spread devastation around it, resumed its slumber for many years. There is no mention of its activity for 130 years after A.D. 73. Then it growled and sent forth steam and cinder-dust to an extent sufficient to attract attention again; its efforts were thereafter recorded once or so in a century, though little, if any, harm was done by it. In A.D. 1139 there was a great throwing-up of dust and stones, with steam, which reflected the light of molten lava within the crater, and looked like flames. And then for close on 500 years there was little, if any, sign of activity. The "eruptions" between that of A.D. 79 and that of A.D. 1139 had been ejections of steam and cinders, unaccompanied by any flow or stream of lava. Then suddenly the whole business shut up for 500 years, and after that—also quite suddenly—in 1631, a really big eruption took place, exceeding in volume the catastrophe of Pliny's date. Not only were columns of dust and vapour ejected to a height of many miles, but several streams of white-hot lava overflowed the edge of the crater and reached the seacoast, destroying towns and villages on the way. Some of these lava-streams were five miles broad, and can be studied at the present day. As many as 18,000 persons were killed.

There were three more eruptions in the seventeenth century, and from that date there set in a period of far more frequent outbursts, which have continued to our own times. In the eighteenth century there were twenty-three distinct eruptions, lasting each from a few hours to two or three days, and of varying degrees of violence—a vast steam-jet forcing up cinders and stones from the crater into

the air, usually accompanied by the outflow of lava, from cracks in the sides of the crater, in greater or less quantity. In the nineteenth century there were twenty-five distinct eruptions, the most formidable of which were those of 1822, 1834, and 1872. All of the eruptions of Vesuvius in the last 280 years have been carefully described, and most of them recorded in coloured pictures (a favourite industry of the Neapolitans), showing the appearance of the active volcano both by day and night and its change of shape in successive years. Sir William Hamilton, the British Ambassador at the Court of Naples at the end of the eighteenth century (of whose great folio volumes I am the fortunate possessor), largely occupied himself in the study and description of Vesuvius, and published illustrations of the kind mentioned above, showing the appearance of the mountain at various epochs. Since his day there has been no lack of descriptions of every succeeding eruption, and now we have the records of photography.

The crater or basin formed by a volcano starts with the opening of a fissure in the earth's surface communicating by a pipe-like passage with very deeply-seated molten matter and steam. Whether the molten matter thus naturally "tapped" is only a local, though vast, accumulation, or is universally distributed at a given depth below the earth's crust, and at how many miles from the surface, is not known. It seems to be certain that the great pressure of the crust of the earth (from five to twenty-five miles thick) must prevent the heated matter below it from becoming either liquid or gaseous, whether the heat of that mass be due to the cracking of the earth's crust and the friction of the moving surfaces as the crust cools and shrinks, or is to be accounted or by the original high temperature of the entire mass of the terrestrial globe. It is only when the gigantic pressure is relieved by the cracking or fissuring of the closed case called "the crust of the earth" that the enclosed deep-lying matter of immensely high temperature liquefies, or even vaporizes, and rushes into the up-leading fissure. Steam and gas thus "set

free " drive everything before them, carrying solid masses along with them, tearing, rending, shaking " the foundations of the hills," and issuing in terrific jets from the earth's surface as through a safety valve, into the astonished world above. Often in a few hours they choke their own path by the destruction they produce and the falling in of the walls of their briefly-opened channels. Then there is a lull of hours, days, or even centuries, and after that again, a movement of the crust, a " giving " of the blockage of the deep, vertical pipe, and a renewed rush and jet of expanding gas and liquefying rock.

The general scheme of this process and its relations to the structure and properties of the outer crust and inner mass of the globe is still a matter of discussion, theory and verification; but whatever conclusions geologists may reach on these matters, the main fact of importance is that steam and gases issue from these fissures with enormous velocity and pressure, and that " a vent " of this kind, once established, continues, as a rule, to serve intermittently for centuries, and, indeed, for vast periods to which we can assign no definite limits. The solid matter ejected becomes piled up around the vent as a mound, its outline taking the graceful catenary curves of rest and adjustment to which are due the great beauty of volcanic cones. The apex of the cone is blown away at intervals by the violent blasts issuing from the vent, and thus we have formed the " crater," varying in the area enclosed by its margin and in the depth and appearance of the cup so produced. At a rate depending on the amount of solid matter ejected by the crater, the mound will grow in the course of time to be a mountain, and often secondary craters or temporary openings, connected at some depth with the main passage leading to the central vent, will form on the sides of the mound or mountain. Sometimes the old crater will cease to grow in consequence of the blocking of its central vent and the formation of one or more subsidiary vents, the activity of which may blast away or smother the cup-like edge of the first crater.

Such a history has been that of Vesuvius shown in outline in Fig. 13. In geologic ages—perhaps some thousands of centuries ago—Vesuvius was probably a perfect cone (its outline is shown at the bottom of p. 27) some 7,000 ft. high, rising by a characteristically accelerated upgrowth from a circle of ten miles or more in diameter to its delicate central peak, hollowed out at the summit by a small crater a couple of hundred yards across. Its eruptions at that time were neither excessive nor violent. Then came a period of greatly increased energy—the steam-jet blew with such violence that it shattered and dispersed the cone, lowering the mountain to 3,700 ft. in height, truncating it and leaving a proportionately widened crater of a mile and a half in diameter. And then the mountain reposed for long centuries. We do not know how long this period of extinction was, for we do not know when it began, but we know that this was the state of the mountain when in A.D. 79 it once more burst into life. In recent years—that is, since the seventeenth century A.D., a curious change took place in the mountain: the vent or orifice of the conducting channel by which eruptive matters were brought to the surface ceased to be in the centre of the wide broken-down crater of Pliny's time, and a vent was formed a few hundred yards to the south of the centre of the old crater, nearer to the south side of the old crater's wall. From this ashes or cinders issued, and were piled up to form a new cone, which soon added 600 ft. to the height of the mountain and covered in the southern half of the old crater's lip, whilst leaving the northern half or semicircle free. This latter uncovered part was called by the Italians "Monte Somma," and the new cone low down in the southern side of which the rest of the old crater-lip could be traced, was henceforth spoken of as "the ash-cone" and sometimes misleadingly as "the true" Vesuvius. Clearly it was not "the true Vesuvius" since it was a new growth. The original old Vesuvius was crowned by a crater formed by the cliffs of Monte Somma and their continuation round to the south side, now more or less completely concealed by the new ash-cone.

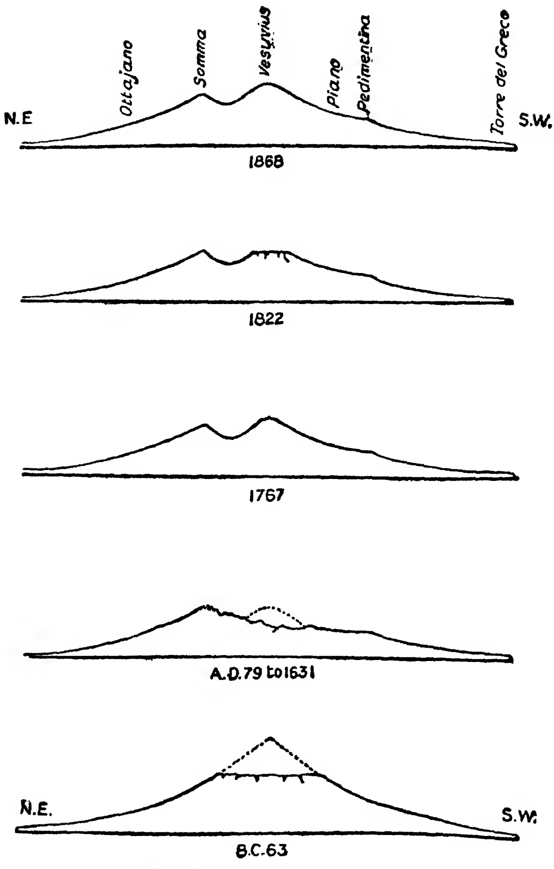


FIG. 13.—Five successive stages in the change of form of Vesuvius (after Phillips's *Vesuvius*, Oxford, 1869). In the oldest (lowest figure) we see the mountain with its still earlier outline completed by the cone drawn in dotted line. Within the period of historic record that cone had not been seen. The mountain had, so far as men knew, always been truncated as shown here and in Fig. 12. The next figure above shows the further lowering of the mountain by the first eruption on record—that which destroyed Pompeii in A.D. 79. The commencing formation of a new ash-cone is indicated by a dotted line. In the three upper figures we trace the gradual growth of the new cone from 1631 to 1868. In 1872 the top of the new ash-cone was blown away, and the mountain reverted to the shape of 1822. Now (1920) the cone has accumulated once more and is higher than it was in 1868.

In the course of various eruptions during the last two centuries the new ash-cone thus formed was blown away more or less completely, and gradually grew up again. During the nineteenth century it was a permanent feature of the mountain, though a good deal cut down in 1822, and later grew so high as to give a total elevation from the sea-level of 4,300 ft. The crater at the top of the ash-cone has varied during the past century in width and depth, according to its building up or blowing away by the central steam jet. In 1822 it is reported to have been funnel-like and 2,000 ft. deep, tapering downwards to the narrow fissures which are the actual vent. At other times it has been largely filled by debris, and only 200 ft. deep. Molten lava has often issued from fissures in the sides of the ash-cone and even lower down on the sides of the mountain, and a very small secondary crater has sometimes appeared on the side of the ash-cone 100 ft. or 200 ft. from the terminal crater which " finishes off " the cone.

Such was the condition of the mountain when I first saw it in the autumn of 1871. Six months later I witnessed the most violent eruption of the nineteenth century. Vesuvius kept up a continuous roar like that of a railway engine letting off steam when at rest in a covered station only a thousandfold bigger. Its vibrations shook with a deep musical note, for twenty-four hours, the house nine miles distant in Naples in which I was staying. My windows commanded a view of the mountain, and when the noise ceased and the huge steam-cloud cleared away, I saw a different Vesuvius, the higher part of the ash-cone was gone, and a huge gap in it had been formed by the blowing away of its northern side.

In October 1871, when I joined my friend Anton Dohrn at Naples in order to study the marine creatures of the beautiful bay, Vesuvius was in the proud possession of a splendid cone, completing its graceful outline. A little steam-cloud hung about one side of the cone during the day, and as night came on Vesuvius used, as we said, to " light his cigar." In fact, a very small quantity of molten

lava was at that time flowing from the side of the ash-cone, about 100 ft. from its summit, and this gave a most picturesque effect as we watched it from the balcony high up on Pausilippo, when the sun set. It was a friendly sort of beacon, far away on the commanding mountain's top, which was answered by the lighting up of a thousand lamps along the coast, and by innumerable flaming faggots in the fishermen's boats moving across the bay, drawing to their light strange fishes, to be impaled by the long tridents of the skilful spearmen. That little beacon light on Vesuvius increased in volume in the course of three weeks, and was supplemented by other flaming streams and by showers of red-hot stones from the crater. This small " eruption " was the precursor by six months of the great eruption of the end of April 1872, and I spent a night on Vesuvius during its progress, and looked into the crater from which the glowing masses of rock were being belched forth.

Not long before I went, in 1871, to Naples I had spent some weeks in visiting the extinct volcanoes of the Auvergne and of the Eiffel, and I was eager to examine the still living Vesuvius. In the first week of October I made an excursion to the crater of Vesuvius in company with the son of a Russian admiral, whose name, " Popoff," was under the circumstances unpleasantly suggestive. We examined some black slaglike masses of old lava-streams, and struggled up the loose sandy ash-cone (there was no " funicular " in those days), and prodded with our sticks the few yards of molten lava which emerged from the side of the cone about 100 ft. from the summit. On Nov. 1 my friend Anton Dohrn (who was then negotiating with the Naples Municipality for a site in the Villa Nazionale on which to erect the great Zoological Station and Aquarium, now so well known) was with me and some Neapolitan acquaintances looking at Vesuvius across the bay from Pausilippo, where we had established ourselves, when we noticed that a long line of steam was rising from the lower part of the ash-cone and that puffs of steam were issuing at intervals from the crater. " Dio mio! Dio di Dio!" cried the

Neapolitans in terror, and expressed their intention of leaving Naples without an hour's delay. As night fell a new glowing line of fire appeared far down near the base of the ash-cone, whilst what looked in the distance like sparks from a furnace, but were really red-hot stones—each as big as a Gladstone bag—were thrown every two or three minutes from the crater.

We hired a carriage, drove to Resina (built above buried Herculaneum), and walked up towards the Observatory in order to spend the night on the burning mountain. We found that two white-hot streams, each about twenty yards broad at the free end, were issuing from the base of the cone. The glowing stones thrown up by the crater were now separately visible ; a loud roar accompanied each spasmodic ejection. The night was very clear, and a white firmly-cut cloud, due to the steam ejected by the crater, hung above it. At intervals we heard a milder detonation —that of thunder which accompanied the lightning which played in the cloud, giving it a greenish illumination by contrast with the red flame colour reflected on to it by red-hot material within the crater. The flames attributed to volcanoes are generally of this nature, but actual flames do sometimes occur in volcanic eruptions by the ignition of combustible gases. The puffs of steam from the crater were separated by intervals of about three minutes. When an eruption becomes violent they succeed one another at the rate of many in a second, and the force of the steam jet is gigantic, driving a column of transparent super-heated steam with such vigour that as it cools into the condition of " cloud " an appearance like that of a gigantic pine-tree seven miles high (in the case of Vesuvius) is produced.

We made our way to the advancing end of one of the lava-streams (like the " snout " of a glacier), which was 20 ft. high, and moved forwards but slowly, in successive jerks. Two hundred yards farther up, where it issued from the sandy ashes, the lava was white-hot and running like water, but it was not in very great quantity and rapidly

cooled on the surface and became "sticky." A cooled skin of slag was formed in this way, which arrested the advancing stream of lava. At intervals of a few minutes this cooled crust was broken into innumerable clinkers by the pressure of the stream, and there was a noise like the smashing of a gigantic store of crockery ware as the pieces or "clinkers" fell over one another down the nearly vertical "snout" of the lava-stream, whilst the red-hot molten material burst forward for a few feet, but immediately became again "crusted over" and stopped in its progress. We watched the coming together and fusion of the two streams and the overwhelming and burning up of several trees by the steadily, though slowly, advancing river of fire. Then we climbed up the ash-cone, getting nearer and nearer to the rim of the crater, from which showers of glowing stones were being shot. The deep roar of the mountain at each effort was echoed from the cliffs of the ancient mother-crater, Monte Somma, and the ground shook under our feet as does a ship at sea when struck by a wave. The night was very still in the intervals. The moon was shining, and a weird melancholy "ritornelle" sung by peasants far off in some village below us came to our ears with strange distinctness. It might have been the chorus of the imprisoned giants of Vulcan's forge as they blew the sparks with their bellows and shook the mountains with the heavy blows of their hammers.

As we ascended the upper part of the cone the red-hot stones were falling to our left, and we determined to risk a rapid climb to the edge of the crater on the right or southern side, and to look into it. We did so, and as we peered into the great steaming pit a terrific roar, accompanied by a shuddering of the whole mountain, burst from it. Hundreds of red-hot stones rose in the air to a height of 400 ft., and fell, happily in accordance with our expectation, to our left. We ran quickly down the sandy side of the cone to a safe position, about 300 ft. below the crater's lip, and having lit our pipes from one of the red-hot "bombs," rested for a while at a safe distance and waited

for the sunrise. A vast horizontal layer of cloud had now formed below us, and Vesuvius and the hills around Naples appeared as islands emerging from a sea. The brilliant sunlight was reassuring after this night of strange experiences. The fields and lanes were deserted in the early morning as we descended to the sea-level. On our way we met a procession of weird figures clad in long white robes, enveloping the head closely but leaving apertures for the eyes. They were a party of the lay-brothers of the Misericordia carrying a dead man to his grave. Then we found our carriage, and drove quickly back to Naples and sleep!

In the following March I acted as guide to my friend Professor Huxley in expeditions up Vesuvius, now quiescent, and to the Solfatara. Then suddenly, in April, the great eruption of 1872 burst upon us. On the first day of the outbreak some imprudent visitors were killed by steam and gas ejected by the lava-stream. By the next day the violence of the eruption was too great for anyone to venture near it. The crater sent forth no intermittent "puffs" as in the preceding November, but a continuously throbbing jet which produced a cloud five miles high, like an enormous cauliflower in shape, suspended above the mountain and making it look by comparison like a mole-hill. Showers of fine ashes, as in the days of Pompeii, fell thickly around, accumulating to the depth of an inch in a few hours even at my house in Pausilippo, nine miles distant across the bay. I was recovering at the time from an attack of typhoid fever, and lay in bed, listening to the deep humming sound and wondering at the darkness until my doctor came and told me of the eruption. I was able to get up and see from the window the great cauliflower-like cloud and the vacant place where the ash-cone was, but whence it had now been scattered into the sky. (It has been gradually reformed by later eruptions, of which the last of any size was in 1906.) I could also see steam rising like smoke from a long line reaching six miles down the mountain into the flat country below. It was the great

lava-stream which had destroyed two prosperous villages in its course.

After ten days I was able to get about, and drove over to one of these villages and along its main street, which was closely blocked at the end by what looked like a railway embankment some 40 ft. high. This was the side of the great lava-stream now cooled and hardened on the surface. It had sharply cut the houses, on each side of the street, in half without setting them on fire, so that the various rooms were exposed in section—pictures hanging on the walls, and even chairs and other furniture remaining in place on the unbroken portion of the floor. The villagers had provided ladders by which I ascended the steep side of the embankment-like mass at the end of the street, and there a wonderful sight revealed itself. One looked out on a great river seven miles long, narrow where it started from the broken-down crater, but widening to three miles where I stood, and wider still farther on as it descended. This river, with all its waves and ripples, was turned to stone, and greatly resembled a Swiss glacier in appearance. A foot below the surface it was still red-hot, and a stick pushed into a crevice caught fire. It was not safe to venture far on to the pie-crust surface. A couple of miles away the campanile of the church of a village called Massa di Somma stood out, leaning like that of Pisa, from the petrified mass, whilst the rest of the village was overwhelmed and covered in by the great stream.

The curious resemblance of the lava-stream to a glacier arose from the fact that it was almost completely covered by a white snow-like powder. This snow-like powder, which often appears on freshly-run lava, is salt—common sea salt and other mineral salts dissolved in the water ejected as steam mixed with the lava. The steam condenses, as the lava cools, into water and evaporates slowly, leaving the salt as crystals. Often these are not white, but contain iron salt, mixed with the white sodium, potassium, and ammonium chlorides, which gives them a yellow or orange colour. Salts coloured in this way have the appearance

of sulphur, and are often mistaken for it. The whole of the interior of the crater of Vesuvius when I revisited it in 1875 was thus coloured yellow, and I have a water-colour sketch of the scene made by a friend who came with me for the purpose. As a matter of fact, though small quantities of the choking gas called "sulphurous acid" are among the vapours given off by Vesuvius, there is no desposit of sulphur there. Some large volcanoes (in Mexico and Japan) have made deposits of sulphur, which are dug for commercial purposes; but the sulphur of Sicily is not, and has not been, thrown out or volatilized by Etna. It occurs in rough masses and in splendid crystals in a tertiary calcareous marine deposit, and its deposition was probably due to a chemical decomposition of constituents of the sea water brought about by minute plants, known as "sulphur bacteria." Whether the neighbouring great volcano had any share in the process seems to be doubtful.

It is generally supposed that sea water makes its way in large quantity through fissures connected with volcanic channels, and is one of the agents of the explosions caused by the subterranean molten matter. Gaseous water, hydrochloric acid, carbonic acid, hydrofluoric acid, and even pure hydrogen and oxygen and argon are among the gases ejected by volcanoes.

The molten matter forced up from the bowels of the earth and poured out by volcanoes is made up of various chemical substances, differing in different localities, and even in different eruptions of the same volcano. It consists largely of silicates of iron, lime, magnesium, aluminium, and the alkali metals, with possible admixture of nearly every other element. Some volcanoes eject "pitch" or "bitumen." When the molten matter cools, interesting crystals of various "species" (i.e., of various chemical composition) usually form in the deeper part of the mass. The lavas of Vesuvius frequently contain beautiful opaque-white twelve-sided crystals of a siliceous mineral called "leucite." I have collected in the lava of Niedermendig, on the Rhine, specimens embedding bright blue transparent

crystals (a mineral called Haüynite) scattered in the grey porous rock. The lava-streams, and even the "roots," of extinct volcanoes which are of great geologic age, sometimes become exposed by the change of the earth's surface, and extensive sheets of volcanic rock of various kinds are thus laid bare. Basalt is one of these rocks, and it not infrequently presents itself as a mass of perpendicular six-sided columns, each column 10 ft. or more high, and often a foot or more in diameter. The "Giant's Causeway," in the North of Ireland, and the "Pavée des Géants," in the Ardêche of Southern France, are examples both of which I have visited. It is not easy to explain how the molten basalt has come to take this columnar structure on cooling. It has nothing to do with "crystallization," but is similar to the columnar formation shown by commercial "starch" and occasionally by "tabular flint." A theoretical explanation of its formation has been given by Prof. J. Thompson, brother of the late Lord Kelvin.

The varieties of volcanoes and their products make up a long story—too long to be told here. There are from 300 to 400 active craters in existence to-day—mostly not isolated, but grouped along certain great lines, as, for instance, along the Andean chain, or in more irregular tracks. If we add to the list craters no longer active, but still recognizable, we must multiply it by ten. Vesuvius is the only active volcano on the mainland of Europe—Hecla, Etna, Stromboli, Volcano, and the volcanoes of the Santorin group are on islands. The biggest volcanoes are in South America, Mexico, Java, and Japan. Volcanoes and the related "earthquakes" have been most carefully studied with a view to the safety of the population in Japan. The graceful and well-beloved volcano, Fujiyama, is more than 12,000 ft. high, but, unlike others in those islands, it has been quiescent now for just 200 years. The most violent volcanic eruptions of recent times, with the largest "output" of solid matter, are those of the Suffrière of St. Vincent in 1812, of the Mont Pelée of Martinique in 1902, and of Krakatoa in 1883. A single moderate eruption

of the great volcano Mauna Loa, in Hawaii, nearly 14,000 ft. high, throws out a greater quantity of solid matter than Vesuvius has ejected in all the years which have elapsed since the destruction of Pompeii. Many hundred millions of tons of solid matter were ejected by Mont Pelée in 1902, when also a peculiar heavy cloud descended from the mountain, hot and acrid, charged with incandescent sand, and rolling along like a liquid rather than a vapour. It burnt up the town of St. Pierre and its inhabitants and the shipping in the harbour. In the eruption of the volcano of St. Vincent in 1812 three million tons of ashes were projected on to the Bahamas Islands, 100 miles distant, besides a larger quantity which fell elsewhere. The great explosion at Krakatoa, lasting two days, blew an island of 1400 ft. high, into the air. A good deal of it was projected as excessively fine needlelike particles of pumice with such force as to carry it up thirty miles into the upper regions of the atmosphere, where it was carried by air currents all over the world, causing the " red sunsets " of the following year. The sky over Batavia, 100 miles distant, was darkened at midday so completely that lamps had to be used—as I heard from my brother who was there at the time. The explosions were heard in Mauritius, 3,000 miles away. A sea wave 50 ft. high was set going by the submarine disturbance, and reaching Java and neighbouring islands inundated the land and destroyed 36,000 persons. This wave travelled in reduced size over a vast tract of the ocean, and was observed and recorded at Cape Horn, 7,800 miles distant from its seat of origin.

QUICKSANDS AND FIRESTONES

THERE are curious facts about sand which can be studied on the seashore. There are the "quicksands," mixtures of sand and water, which sometimes engulf pedestrians and horsemen at low tide, not only at the Mont St. Michel, on the Normandy coast, but at many spots on the English, Welsh, and Scotch coasts. Small and harmless quicksands are often formed where the sand is not firmly "bedded" by the receding sea, and the sea water does not drain off, but forms a sort of sand-bog. Then one may also study the polishing and eroding effect of dry blown sand, which gives a "sand-glaze" to flints, and in "sand-deserts" often wears away great rocks. The natural polishing of flints and other hard bodies by fine sand carried over them for months and years in succession by a stream of water, is also a matter of great interest, about which archæologists want further information.

A very interesting fact about the ordinary sand of the seashore is that two pints of dry sand and half a pint of water when mixed do not make two pints and a half, but less than that quantity. If you fill a child's pail with dry sand from above the tide-mark, and then pour on to it some water, the mass of sand actually shrinks. The reason is that when the sand is dry there is air between its particles, but when the sand-particles are wetted they adhere closely to each other; the air is driven out, and the water does not exactly take an equivalent space, but occupies less room than the air did, owing to the close clinging together of the wet particles. If you add a little water to some dry sand under the microscope, you will see the sand-particles move and cling closely to one another. "Capillary attraction"—the ascent of liquid in very fine tubes or spaces—is a result of the same sort of adhesive action. If you walk on the firm, damp sand exposed at low tide on

many parts of the seashore when it is just free from water on the surface, you will see that when you put your foot down the sand becomes suddenly pale for some seven inches or so all round your foot. The reason is that the water has left the pale-looking sand (dry sand looks paler than wet sand), and has gone into the sand under your foot, which is being squeezed by your weight. The water passing into that squeezed sand enables its particles to sit tighter or closer together, and so to yield to the pressure caused by your weight. You actually draw water "into" the sand, instead of squeezing water "out" of it, as is usually the case when you squeeze part of a wet substance—say a cloth or a sponge. When you lift your foot up, you find that your footmark is covered with water—the water you had drawn to that particular spot by squeezing it. It separates as soon as the pressure is removed.

Quartz and quartzite pebbles occur on the South as well as the East Coast. They are sometimes called "fire-stones," because they can be made to produce flashes of flame. If you take a couple of these pebbles, each about as big as the bowl of a dessert-spoon (a couple of flint pebbles will serve, but not so well), and holding one in each hand in a dark room, or at night, scrape one with the other very firmly, you will produce a flash of light of an orange or reddish colour. And at the same time you will notice a very peculiar smell, rather agreeable than otherwise, like that of burning vegetable matter. It would seem that the rubbing together of the stones produces a fine powder of some of the siliceous substance of the stone and at the same time a very high temperature, which sets the powder aflame. I had the idea at one time, based on the curious smell given out by the flashing pebbles, that perhaps it was a thin coating of vegetable or other organic matter derived from the sea water which burns when the stones are thus rubbed together; but I found on chemically cleaning my pebbles, first with strong acid and then with alkali, that the flame and the smell were produced just as well by these chemically clean stones as by those taken

from the beach. The flame produced by the rubbing of the two stones seemed then to be like the sparks obtained by strike-a-lights of flint and steel, or the prehistoric flint and pyrites. Now, however, a new fact demands consideration. The supposition that the powdered silica formed, when one rubs the two pebbles together, is actually "burnt," that is to say, combined with the oxygen of the air by the great heat of the friction, is rendered unlikely by the fact that if you perform the rubbing operation in a basin of water with the stones submerged, the flash is produced as easily as in the air. My attention was drawn to this fact by a letter from the well-known naturalist the Rev. Reginald Gatty. I at once tried the experiment and found the fact to be as my correspondent stated. Not only so, but the smell was produced as well as the flash.

With the desire to get further light on the subject, I consulted the great experimental physicist, my friend Sir James Dewar, in his laboratory at the Royal Institution. He told me that the late Professor Tyndall used to exhibit the production of flame by the friction of two pieces of quartz in his lectures on heat, but made use of a very large and rough crystal of quartz (rock-crystal) and rubbed its rough surface with another large crystal. Tyndall's note on the subject in his lecture programme was as follows (Juvenile Lectures on Heat, 1877–78): "When very hard substances are rubbed together light is produced as well as heat." Sir James Dewar kindly showed me the crystals used by Tyndall, the larger was 16 inches long and 4 or 5 inches broad. We repeated the experiment in the darkened lecture room, and obtained splendid flashes. The same smell is produced when rock-crystal is used as when flint or quartz pebbles are rubbed together. All three are the same chemical body, namely, silica (oxide of silicon). We also found that when the crystals were bathed with water or (this is a new fact) with absolute alcohol, the same flashing was produced by the friction of one against the other.

Later, with the kind assistance of Mr. Herbert Smith, of

the mineral department of the Natural History Museum, I examined, with a spectroscope, the flash given by two quartzite pebbles when rubbed together. No distinctive lines or bands were seen ; only a " continuous " spectrum, showing that the temperature produced was not high enough to volatilize the silicon. I also examined some pebbles of another very hard substance—harder than silica (rock-crystal, quartz, and flint). This was what is called " corundum," the massive form of " emery powder " (oxide of aluminium). By grinding two of these corundum pebbles with very great pressure one against the other (using much greater pressure than is needful in the case of quartz), I obtained flashes of light. It was not known previously that any pebbles except those of silica would give flashes of light when rubbed together. A smell resembling that given out by rubbed quartz, but fainter, was observed.

Those are the facts—new to me and to many others—about this curious subject. The flashing under water is a very remarkable thing. I cannot say that I am yet satisfied as to the nature of the flash. A simple explanation of the result obtained, when two dry pebbles are rubbed together in the air, is that crushed particles of the quartz or of the corundum are heated by the heavy friction to the glowing point. But this does not accord with the fact that submergence in a liquid does not interfere with the flashing. The rise of temperature would certainly be checked by the liquid. And the curious smell produced is in no way explained.

The breaking of crystals is in many instances known to produce a flash of light. Thus a lump of loaf sugar broken in the dark gives a faint flash of blue light, as anyone can see for himself immediately on reading this. White arsenic crystals also, when broken by shaking the liquid in which they have formed, give out flashes of light. Some rare specimens of diamond, when rubbed in the dark with a chamois leather, glow brightly. The well-known mineral called Derbyshire spar, " Blue John," or fluoride of calcium,

when heated to a point much below that of a red-hot iron, "crackles" and glows briefly with a greenish light. The crystals of phosphate of lime, called apatite, and a number of other crystals have this property. But there is no record of any peculiar smell accompanying the flashes of light. It is still a matter open to investigation as to whether the flashing of pieces of quartz and rock-crystal when rubbed together with heavy pressure is of the nature of the flashing of the heated crystals of other minerals, or whether there is any chemical action set up by the friction —an action which is certainly suggested by the very peculiar smell produced. Since the flashing can be produced under water and other liquids, it should be easy to obtain some evidence as to the chemical nature of the flame—whether acid or alkaline, whether capable of acting on this or that reagent dissolved in the water, and whether setting free any gas of one kind or another.

Any one of my readers who chooses can produce the wonderful orange-coloured flame by rubbing two quartz or flint pebbles together in the dark, and can have the further gratification of producing with the utmost ease the mysterious and weird phenomenon of a flame under water, and may, perhaps, by further experiment, explain satisfactorily this unsolved marvel which has haunted some of us since childhood.

THE JEWEL IN THE TOAD'S HEAD

TO what jewel or precious stone was Shakespeare alluding when he makes the exiled Duke in *As You Like It* (after praising his rough life in the forest of Arden, and declaring that adversity has its compensations), exclaim :

> " The toad, ugly and venomous,
> Wears yet a precious jewel in his head " ?

No doubt the unprejudiced reader supposes when he reads this passage that there is some stone or stone-like body in the head of the toad which has a special beauty, or else was believed to possess magical or medicinal properties. And it is probable that Shakespeare himself did suppose that such a stone existed. As a matter of fact there is no stone or " jewel " of any kind in the head of the common toad nor of any species of toad—common or rare. This is a simple and certain result of the careful examination of the heads of innumerable toads, and is not merely " common knowledge," but actually the last word of the scientific expert. In these days of " nature study " writers familiar with toads and frogs and kindred beasts have puzzled over Shakespeare's words, and suggested that he was really referring to the beautiful eyes of the toad, which are like gems in colour and brilliance.

This, however, is not the case. Shakespeare himself was simply making use of what was considered to be " common knowledge " in his day when he made the Duke compare adversity to the toad with a magic jewel in its head commonly known as " a toad-stone," although that " common knowledge " was really not knowledge at all, but—like an enormous mass of the accepted current statements in those times, about animals, plants and stones —was an absolutely baseless invention. Such baseless

beliefs were due to the perfectly innocent but reckless habit of mankind, throughout long ages, of exaggerating and building up marvellous narrations on the one hand, and on the other hand of believing without any sufficient inquiry, and with delight and enthusiasm, such marvellous narrations set down by others. Each writer or "gossip" concerning the wonders of unexplored nature, consciously or unconsciously, added a little to the story as received by him, and so the authoritative statements as to marvels grew more and more astonishing and interesting.

It was not until the time of Shakespeare himself that another spirit began to assert itself—namely, that of asking whether a prevalent belief or tradition is actually a true statement of fact. Men proceeded to test the belief by an examination of the thing in question, and not by merely adducing the assertions of "the learned so-and-so," or of "the ingenious Mr. Dash." This spirit of inquiry actually existed in a fairly active state among the more cultivated of the ancient Greeks. Aristotle (who flourished about 350 B.C.), though he could not free himself altogether from the primitive tendency to accept the marvellous as true because it is marvellous and without regard to its probability—in fact because of its improbability—yet on the whole showed a determination to investigate, and to see things for himself, and left in his writings an immense series of first-rate original observations. He had far more of the modern scientific spirit than had the innumerable credulous writers of Western Europe who lived fifteen hundred to two thousand years after him. Even that delightful person Herodotus, who preceded Aristotle by a hundred years, occasionally took the trouble to inquire into some of the wonders he heard of on his travels, and is careful to say now and then that he does not believe what he heard. But the mediaeval makers of "bestiaries," herbals, and treatises on stones, which were collections of every possible fancy and "old-wife's tale," about animals, plants, and minerals, mixed up with Greek and Arabic legends and the mystical, medical lore of the *Physiologus*—

that Byzantine cyclopædia of "wisdom while you wait"—deliberately discarded all attempt to set down the truth; they simply gave that up as a bad job, and recorded every strange story, property and "application" (as they termed it) of natural objects with solemn assurance, adding a bit of their own invention to the gathered and growing mass of preposterous misunderstanding and superstition.

In the seventeenth century the opposition to this method of omnivorous credulity (which even to-day, in spite of all our "progress," flourishes among both the rich and the poor) crystallized in the purpose of the Royal Society of London for the Improvement of Natural Knowledge—whose motto was, and is "*Nullius in verba*" (that is, "We swear by no man's words"), and whose original first rule, to be observed at its meetings, was that no one should discourse of his opinions or narrate a marvel, but that any member who wished to address the society should "bring in," that is to say, "exhibit" an experiment or an actual specimen. A new spirit, the "scientific" spirit, gave rise to and was nourished by this and similar societies of learned men. As a consequence the absurdities and the cruel and injurious beliefs in witchcraft, astrology, and baseless legend, melted away like clouds before the rising sun. In the place of the mad nightmare of fantastic ignorance, there grew up the solid body of unassailable knowledge of Nature and of man which we call "science"—a growth which made such prodigious strides in the last century that we now may be truly said to live in the presence of a new heaven and a new earth!

It was, then, a real "stone," called the toad-stone, to which Shakespeare alluded. It is mentioned in various old treatises concerning the magical and medicinal properties of gems and stones under its Latin name, "*Bufonius lapis*," and was also called Borax, Nosa, Crapondinus, Crapaudina, Chelonitis, and Batrachites. It was also called Grateriano and Garatronius, after a gentleman named Gratterus, who in 1473 found a very large one, reputed to have marvellous power. In 1657, in the "translation by a person of

quality" of the *Thaumatographia* of a Polish physician named Jonstonus, we find written of it: "Toads produce a stone, with their own image sometimes. It hath very great force against malignant tumours that are venomous. They are used to heat it in a bag, and to lay it hot, without anything between, to the naked body, and to rub the

FIG. 14.—Representation of a man extracting the jewel from a toad's head; two "jewels" already extracted are seen dropping to the ground. From the *Hortus Sanitatis*, published in 1490.

affected place with it. They say it prevails against inchantments of witches, especially for women and children bewitched. So soon as you apply it to one bewitched it sweats many drops. In the plague it is laid to the heart to strengthen it." Another physician of the same period (see *Notes and Queries*, fourth series, vol. vii, 1871, p. 540) appears to be affected by the new spirit of inquiry, for he relates the old traditions about the stone and how he

tested them. He says it was reported that the stone could be cut out of the toad's head. (In the book called *Hortus Sanitatis*, dated 1490, there is a picture here reproduced (Fig. 14) of a gentleman performing this operation successfully on a gigantic toad.) Our sceptical physician, however, goes on to say that it was commonly believed that these stones are thrown out of the mouth by old toads (probably the tongue was mistaken for the stone), and that if toads are placed on a piece of red cloth they will eject their " toad-stones," but rapidly swallow them again before one can seize the precious gem! He says that when he was a boy he procured an aged toad and placed it on a red cloth in order to obtain possession of " the stone." He sat up watching the toad all night, but the toad did not eject anything. " Since that time," he says, " I have always regarded as humbug (' badineries ') all that they relate of the toad-stone and of its origin." He then describes the actual stone which passes as the toad-stone, or " *Bufonius lapis*," and says that it is also called batrachite, or brontia, or ombria. His description exactly corresponds with the " toad-stones " which are well known at the present day in collections of old rings.

I have examined twelve of these rings in the British Museum, through the kindness of Sir Charles Read, P.S.A., the Keeper of Mediaeval Antiquities, and four in the Ashmolean Museum at Oxford. Two of these are of chalcedony, with a figure of a toad roughly carved on the stone, and are of a character and origin different from the others. The others, which are the true and recognized " toad-stone " or " *Bufonius lapis*," are circular, slightly convex " stones," of a drab colour, with a smooth, enamel-like surface. They are plate-like discs, being of thin substance and concave on the lower surface, which has an upstanding rim. I recognized them at once as the palatal teeth of a fossil fish called " Lepidotus," common in our own oölitic and wealden strata, and in rocks of that age all over the world. I give in Fig. 15 a drawing of a complete

set of these teeth and of a single one detached. They were white and colourless in life, but are stained of various colours according to the nature of the rock in which they are embedded. A drab colour like that of the skin of the common toad is given to them by the iron salts present in many oölitic rocks; those found in the wealden of the

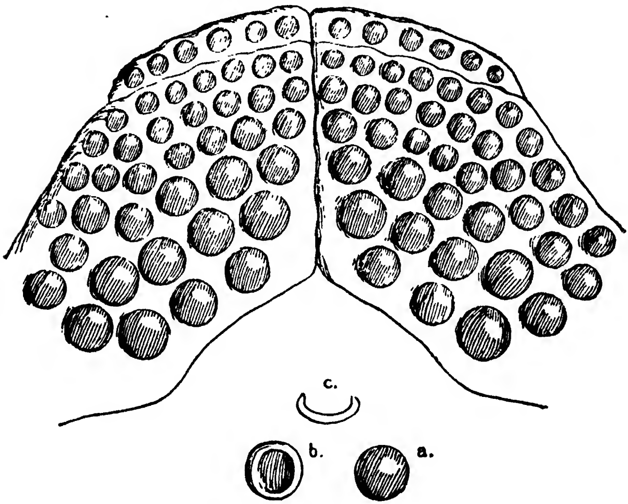


FIG. 15.—The palate of the fossil fish Lepidotus, showing the studlike teeth in position. These are often found singly, and stained of a dull brown colour by the rock in which they were embedded. It was the colour of these fossil teeth, like that of a toad's body, which led to the assertion that they were produced in the head of the toad. *a*. A single detached tooth or "toad-stone" seen from the bright unattached surface. *b*. The same seen from the attached surface. *c*. A section of the tooth showing its cup-like shape. (Original drawings.)

Isle of Wight are black. That the "toad-stones" mounted in ancient rings are really the teeth of a fish has been already recorded by the Rev. R. H. Newell (*The Zoology of the English Poets*, 1845), but he seems to be mistaken in identifying them with those of the wolf-fish (Anarrhicas). They undoubtedly are the palatal teeth of the fossil extinct ganoid fish Lepidotus.

Before leaving the queer inventions and assertions of the old writers about these fossil teeth, which they declared to be taken out of the toad's head, let me quote one delightful passage from a contemporary of Shakespeare (Lupton, *A thousand notable things of sundry sortes. Whereof some are wonderful, some strange, some pleasant, divers necessary, a great sort profitable, and many very precious*, London, 1595). "You shall know," he says, "whether the Toadstone called 'crapaudina' be the right and perfect stone or not. Hold the stone before a toad, so that he may see it. And if it be a right and true stone, the toad will leap towards it and make as though he would snatch it from you; he envieth so much that a man should have that stone. This was credibly told Mizaldus for truth by one of the French King's physicians, which affirmed that he did see the trial thereof."

We have thus before us the actual things called toadstones, and believed by Shakespeare and his contemporaries to be found in the head of the toad. How did it come about that these pretty little button-like, drab-coloured fossil teeth were given such an erroneous history? This question was answered by the late Rev. C. W. King, Fellow of Trinity College, Cambridge, in his book on *Antique Gems* (London, 1860). He says, "I am not aware if any substance of a stony nature is ever now discovered within the head or body of the toad. Probably the whole story originated in the name Batrachites (frog-stone or toadstone), given in Pliny to a gem brought from Coptos, and so called from its resemblance to that animal in colour." We have not, it must be noted, any specimens of the toadstone at the present day actually known to have been brought from Coptos. It is quite possible that the fossil fish-tooth was substituted ages ago for Pliny's Batrachites, and was never found at Coptos at all! Whether that is so or not, the fact is that Pliny never said it came out of a toad, but merely that it was of the colour of a toad.

The Pliny referred to is Pliny the Elder, the celebrated

Roman naturalist who wrote a great treatise on natural history, which we still possess, and died in A.D. 79 whilst visiting the eruption of Vesuvius. He says nothing of the Batrachites being found inside the toad, nor does he mention its medicinal virtues. The name alone—simply the name "Batrachites," the Greek for toad-stone—was sufficient to lead the fertile imagination of the mediaeval doctors to invent all the other particulars! It is a case precisely similar to that of the old lady who was credited with having vomited "three black crows." When the report was traced step by step to its source it was found that her nurse had stated that she vomited something as black as a crow!

The belief in the existence of a stone of magical properties in the head of the toad is only one of many instances of beliefs of a closely similar kind which were accepted by Pliny (although he records no such belief as to the toad-stone), and were passed on from his treatise on natural history in a more or less muddled form to the middle ages, and so to our own time by later writers. Thus Pliny cites, as stones possessing magical properties, the "Bronte" found in the head of the tortoise, the Cinædia in the head of a fish of that name, the Chelonites, a grass-green stone found in a swallow's belly, the Draconites, which must be cut out of the head of a live serpent, the Hyænia from the eye of the Hyena, and the Saurites from the bowels of a green lizard. All these and the Echites, or viper-stone, were credited with extraordinary magical virtues, and many of the assertions of later writers about the toad-stone are clearly due to their having calmly transferred the marvellous stories about other imaginary stones to the imaginary toad-stone. The only stone in the above list which has a real existence is that in the fish's head. Fish have a pair of beautiful translucent stones in their heads—the ear-stones or otoliths—by the laminated structure of which we now can determine the age of a fish just as a tree's age is told by the annual rings of growth in the wood of its stem. The freshwater crayfish has a very curious pair of

opaque stones (concretions of carbonate and phosphate of lime) formed in its gizzard as a normal and regular thing. They are familiar to every student who dissects a crayfish, and I am told that in Germany to-day, as in old times also, the "krebstein" is regarded by the country-folk as possessed of medicinal and magical properties. I am not able, on the present occasion, to trace out the possible origin of all the stories and beliefs about stones occurring within animals. They are more numerous than those cited by Pliny; they exist in every race and every civilization and refer to a large variety of animals. Probably many of these beliefs date from prehistoric times. In the East the most celebrated of these stones, since the period of Arabic civilization, is called a bezoar-stone. "Bezoar" is the Persian word for "antidote," and does not apply only to a stone. The true and original "bezoar-stone" of the East is a concretion found in the intestine of the Persian wild goat. Those which I have seen are usually of the size and shape of a pigeon's egg and of a fine mahogany colour, with a smooth, polished surface. The Persian goat's bezoar-stone is found, on chemical analysis, to consist of "ellagic acid," an acid allied to gallic acid, the vegetable astringent product which occurs in oak-galls used until lately in the manufacture of ink. The bezoar-stone is probably a concretion formed in the intestine from some of the undigested portions of the goat's food. Such concretions are not uncommon, and occur even in man. "Bezoar-stones" are obtained in the East from deer, antelopes, and even monkeys, as well as goats, and must have a different chemical nature in each case. Minute scrapings from these stones are used in the East as medicine, and their chemical qualities render their use not altogether absurd, though they probably have not any really valuable action. It is probable that their use had a later origin than that of the "stones" connected with magic and witchcraft. Sixteenth-century writers, ever ready to invent a history when their knowledge was defective, declared the bezoar-stone to be formed by the inspissated tears of the deer or of the

gazelle—the "gum" which Hamlet remarked in aged examples of the human species.

The substance called "ambergris" (grey amber), valued to-day as a perfume, is a fæcal concretion similar to a bezoar-stone. It is formed in the intestine of the sperm-whale, and contains fragments of the hard parts of cuttle-fishes, which are the food of these whales. "Hair-balls" are formed in the intestines of various large vegetarian animals—and occasionally stony concretions of various chemical composition are formed in the urinary bladder of various animals, as well as of man. The "eagle-stone" is also a concretion to which magical properties were ascribed. I have seen a specimen, but do not know its history and origin. Glass beads found in prehistoric burial-places are called by old writers "adders' eggs," and "adder-stones," and were said (it is improbable that one should say "believed") to hatch out young adders when incubated with sufficiently silly ceremonies and observances. A celebrated "stone" of medicinal reputation in the East is the "goa-stone." This is a purely artificial product—a mass of the size and shape of a large egg, consisting of some very fine and soft powder like fullers'-earth, sweetly scented, and over-laid with gold-leaf. A very little is rubbed off, mixed with water, and swallowed, as a remedy for many diseases. The deep connection of medicine with magic, throwing light on the strange application of stones and hairs, bones and skins, by imaginative mankind, in all ages and places, is exhibited in the common practice of writing with ink a sentence of the Koran (or other sacred words) on a tablet, washing off the ink and making the patient swallow the water in which the sacred phrase has been thus dissolved! How convenient it would be were it possible thus to impart knowledge, virtue, and health to suffering humanity!

A good example of one of the ways in which magical properties become attributed to natural objects is the stone known as amethyst. The ancient Indian name of this

stone had the sound represented by its present name. In Greek this sound happens to mean "not intoxicated"; hence, without more ado, the ancients declared that the amethyst was a preventive of, and a cure for, drunkenness.

THE CONSTITUENTS OF A SEABEACH

I ONCE went down to Aldeburgh, on the Suffolk coast, with a party of friends, which included an American writer, himself as delightful and charming as his stories. Why should I not give his name? It was Cable, the author of *Old Creole Days*. We walked through the little town to the sea-front, and came upon the immense beach spreading out for miles towards Orford Ness. "Well, I never!" said he to me; "I suppose the hotel people have put those stones there to make a promenade for the visitors. It's a big thing." It took me some time to persuade him that they were brought there by the sea and spread out by it alone. It was his first visit to Europe, but he had seen the seashore on the other side, and there was nothing like this over there, he declared. When he once realized that the great Aldeburgh beach was a natural production, he did what a true poet and naturalist must do—he fell in love with it, and spent hours in filling his pockets with strange-looking pebbles of all kinds until he was brought into the house to dinner by main force, when he spread his collection on the table, and demanded an explanation of "what, whence, and why" in regard to each pebble. Our companions—a great lawyer, a military hero, a politician, and two "learned men"—regarded him as eccentric, not to say childish. But I entirely sympathized with him, and when next day we sailed down to Orford and stood in front of the old Norman fortress, he further established himself in my regard by deeply sighing and exclaiming, "So that is a real English castle!" whilst several large tears quietly streamed down his undisturbed countenance.

To give an idea of what various rocks from far-distant localities may be brought together on an East Coast beach, take that of Felixstowe as an example. What is true of

the East Coast is to some extent also true of the South Coast, and, indeed, wherever the sea makes the pebbles of a modern beach from the materials furnished by the breaking up of old deposits, which were in their day brought by ice-flows or torrential currents from remote regions. The most abundant kind of pebbles on the Felixstowe beach are small, rounded, somewhat flat pieces of flint, derived, not directly from the chalk which is the "stratum" or "bed" in which flint is originally formed, but from the Red Crag capping the clay cliffs (London clay or early Eocene), and also from surface washings and "gravels" (of later age than the crag) farther north, whence they have travelled southward with many other constituents of the beach. All these flints are stained ruddy brown or yellow by iron—a process they underwent when lying in the gravels or in the crag in which they were deposited as pebbles, broken, washed, and rolled ages ago from the chalk. The iron is in a high state of oxidation, and stains not only flint pebbles but the sands of the Red Crag and later gravels a bright orange-red, or sometimes a less ruddy yellow. The iron comes originally from very ancient igneous rocks in which it is black and usually combined with silica. The chalk flints are always, owing, it seems, to minute quantities of carbon, quite black in the mass, but thin, translucent splinters have a yellowish-brown tint. The flints are free from iron stain when taken direct from the chalk. The commonest pebble next to flint is milky quartz, or opaque white quartz. This is derived from some far northern source, where there are igneous rocks traversed by veins of this substance (perhaps Norway). Quartz, like flint, is pure silica, the oxide of the element silicon. It appears in another form as rock-crystal, and also as chalcedony and agate. Opal also is pure silica, but differs from quartz and its varieties in being non-crystalline or amorphous, and in being less hard and of less specific gravity than quartz. Opal is soluble in alkaline water containing free carbonic acid, such as are many natural waters and the sea. But quartz is not so. The siliceous "spicules" and skeletons

of many microscopic animals and plants are "opal." The gem known as "opal" is a variety owing its beauty to minute fissures in its substance which break up light into the prismatic colours.

A great deal rarer than the milky quartz, but well known on the East Coast on account of their beauty, and often sought for to be cut and polished, are the small rolled bits or pebbles of chalcedony or agate, which have been bedded before their appearance on the beach in some of the pre-glacial or post-glacial gravels, together with the flints, and in consequence are often stained of a fine red. Such clear red-stained chalcedony is called "carnelian"; if the banded agate structure shows, it is called agate rather than carnelian. It is wonderful how many beautiful pieces of both carnelian and agate are picked up on the Felixstowe beach, rarely, however, bigger than a hazel nut. The original source of these carnelians and agates is the East of Scotland. At Montrose you may see the igneous rock containing pale, lavender-coloured agate nodules as big as a potato, the breaking and rolling of which by the sea into small bits has furnished our Suffolk carnelians. Quartzite—more or less translucent, sandy-looking pebbles, colourless or yellow: jasper, black or green with red veining: a fine wine-red or purple stone often veined with quartz—are all more or less common, and come from northern igneous rocks—possibly some from Scandinavia and some from the breaking up of an ancient "breccia" of the Triassic age, which still exists northwards of East Anglia.

Other pebbles very common on this shore are those formed in a curious way by the sea water from the clay cliffs and sea bottom which are here present, and are of that special geologic age and character known as the London clay. The sea at this moment is continually converting the clay of our Suffolk shore into "cement-stone" by a definite chemical process. The clay and many other things submerged in the sea, as Shakespeare knew, "undergo a sea-change." The cement-stone used to be

dredged up from the sea bottom and ground to make cement at Harwich. Great rock-like slabs of it pave the shore at low water, and pebbles of it are abundant. The curious thing is that ages ago—geological ages, I mean—when the sea was throwing up here the old shell-banks and sand-banks known nowadays as "the Red and Coralline Crags," the London clay cliffs and clay sea bottom were in existence just as they are now. But in that period there existed here enormous quantities of bones of whales of kinds now extinct, which had lived a little earlier in the sea of this area, and were deposited in vast quantity as a sort of first layer of beach or shallow-water sea-drift. Bones consist largely of phosphate of lime, and are used as manure. In that old crag sea the phosphate of lime was dissolved from the deposit of bones, and as we find occurring in the case of other clays and other bones elsewhere—was chemically taken up by the clay—the same kind of clay which to-day is being converted into "cement-stone." It was thus, at that remote period, converted into "clay phosphorite," owing to the presence of the immense deposit of whales' bones, and it has been known for sixty years as Suffolk "coprolite," owing to a mistaken notion that it was the petrified dung of extinct animals. It has been dug up by the ton from below the crag all over this part of Suffolk, where it forms, together with bones, teeth, flints, and box-stones, a bed of small nodules, a foot or so thick separating the London clay from the shelly "crag." This bed is called the Suffolk bone-bed or nodule-bed. The phosphorite, or "coprolite," occurs in the form of bits of clay, hardened by phosphate of lime, and of the colour of chocolate, and hundreds of tons of it have been used by manufacturers of the manure known as "superphosphate." Henslow, of Cambridge, Darwin's friend and teacher, was the first to point out its value. Bits of it, as well as box-stones, and fragments of bone, teeth of whales, of shark, of mastodon, rhinoceros, tapir, and other extinct animals—all fallen from the bone-bed in the cliff—are found mixed with the pebbles of the Suffolk beach by those who lie on

that beach in the sunshine, and, for want of something better to do, turn over handful after handful of its varied material. And, besides all the stones I have already mentioned, they find amber, washed here by some mysterious currents from the Baltic, wonderful fossil shells out of the crag, the cameo shell, and the great volute,—shells which are as friable as the best pastry when dug out of the Red Crag, but here on the shore become hardened by definite chemical action of the sea water, so as to be as firm as steel. Here, too, the "chiffonier" of the seashore finds recent shells, recent bones (slowly dissolving and wearing away), well-rounded bits of glass, jet drifted down from Whitby, Roman coins, bits of Samian ware (!), mediaeval keys, bits of coal, burnt flints (from steamers' furnaces), and box-stones.

A very important and interesting thing about "beaches" is the way in which the pebbles of which they consist are assorted in sizes. Suppose that one prepares a trough some two or three yards long and twelve inches deep, and lets it fill with water from a constantly running tap, tilting it slightly so that the water will overflow and run away at the end farthest from the tap. Then if one drops into the trough near the tap handful after handful of coarse sand and small stones of varied sizes, they will be carried along by the stream, and the more rapid and voluminous the stream the farther they will be carried. But they will eventually sink to the bottom of the trough, the bigger pieces first, then the medium-sized, then the small, and the smaller in order, as the current carries them along, so that one gets a separation and sorting of the solid particles according to size, a very fine sediment being deposited last of all at the far end of the trough. The waves of the sea are continually stirring up and assorting the constituents of the beach in this way. Usually the largest pebbles are thrown up farthest by the advancing waves, and dropped soonest by the backward suck of the retreating water, so that one generally finds a predominance of big pebbles at the top of the beach. But on the

flat shore of firm ripple-marked sand lying lower down than the sloping "beach" and only exposed at quite "low tide," one often finds very big pebbles of eight or nine pounds weight scattered here and there and little rubbed or rounded. They have gradually moved down the sloping beach and are too heavy to be thrown up again by the waves of the shallow sea which flows over the flat shores characteristic of much of our south-eastern and southern coast. On some parts of the coast huge banks, consisting exclusively of enormous pebbles as big as a quartern loaf, are piled up by the waves, forming a great ridge often miles in length, as at the celebrated Chesil pebble bank near Weymouth, and at Westward Ho! in North Devon. The presence of these specially large pebbles is due to the special character of the rocks which are broken up by the sea to form them, and to the specially powerful wave-compelling winds and tidal currents at the parts of the coast where they are produced.

One generally finds a selected accumulation of moderate-sized pebbles lower down the beach as the tide recedes, and then still lower down patches of sand alternating with patches or tracts of quite small pebbles not much bigger than a dried pea. They are always assorted in sizes, but the extent of each tract of a given size of pebble varies greatly on different beaches along the coast, and even from day to day on the same shore. The greater or less violence of the waves, and of the currents caused by wind and tide, is the cause of this variation and local difference. The pebbles of the "beach" are, of course, always being worn away, rounded and rubbed down by their daily movement upon one another, caused by the waves as the tide mounts and again descends over the shore. Even the biggest stones, excepting those which lie in deeper water beyond the beach, are eventually rubbed down, and become quite small; but a point is reached when, the weight of the pebbles being very small, they have but little effect in rubbing down each other, and consequently where the pebbles consist of very hard material—like flints—the smallest ones are

not so much rounded, but are angular and irregular in shape.

Whilst a perfect gradation in size can be found from the largest flint pebbles some 6 inches or 7 inches long to the smallest, usually not bigger than a split pea (though sometimes a patch of even smaller constituents may be found), there is a real break or gap between " pebbles " and " sand." I am referring now to what is commonly known as " sand " on the southern part of the East Coast, much of the South Coast, and the shores of Holland, Belgium, and France. There are " sands " of softer material (limestone and coral sand), but the sands in question are almost entirely siliceous, made up of tiny fragments of flint, of quartz, agate, and hard igneous rock. They are often called " sharp " sand. The particles forming this sand are sorted out by the action of moving water, and form large tracts between tide-marks looking like brown sugar, for which baby visitors have been known to mistake them, and accordingly to swallow small handfuls. The strong wind from the sea blows the sand thus exposed, as it dries, inland out of reach of the tide, to form sand-dunes, and it is also deposited, together with still finer particles (those called " mud "), on the shallower parts of the sea bottom. The curious thing about the particles of " sharp " sand is that they are angular, and for the most part without rounded edges. If you examine them under a microscope you will see that they do not look like pebbles—in fact, they are not pebbles, for they are so small and have so little weight, or, rather, mass, that they do not rub each other to any effect when moved about in water. They look like, and, in fact, are, for the most part broken bits of silica, unworn and sharp-edged splinters and chips, glass-like in their transparency and most of them colourless, a few only iron-stained and yellow. Amongst these are a few rounded, almost spherical pieces, which are no doubt of the nature of minute water-worn pebbles. Although these few minute pebbles exist among the sharp, chiplike particles of " sand," it is clear that we must broadly distinguish

"pebbles" of all sizes down to the smallest—from the much smaller "sand particles." There is no intermediate quality of material between "sand" and the finest "shingle."

THE JUMPING BEAN

ONE way of thinking of the six hundred thousand kinds or species of insects—those tiny, ubiquitous fellow-creatures of ours which inhabit nearly every corner and cranny of the earth's surface—is to associate them with the plants upon which, either for food or protection, the greater number of them are dependent. This makes them appear less overwhelming in their astonishing and, at first sight, meaningless variety, than when one calls them to mind pinned out in long lines in innumerable drawers and cases, or assorted, like with like, in the wonderfully accurate and interminable pictures of them produced by those patient benefactors of mankind the systematic entomologists. Every plant of any size has a number of insects associated with it, living more or less completely on its substance, or making its home in some part of the plant. Some trees are known to have more than a hundred and fifty kinds or species of insects thus dependent on them, those which are vegetarian serving in their turn as food to a variety of carnivorous insects.

The ways in which insects are associated with plants may be briefly stated. It must be remembered that often, though not always, one particular species of plant, and that only, is capable of serving the needs of a given species of insect. Thus, the leaves of a given plant are the necessary food of the grubs of one or more insects which bite their food; its internal juices serve others which suck; its roots others; its nectar in the flower others, which in return serve the plant by carrying away its pollen and fertilizing the other plants of the same species which they visit. Protection is sought and obtained from the same plant by insects which burrow in its leaves, or roll them up, or cut them into slices and carry them away, or hide in its bark, or in the flowers, or in other parts—or burrow for food and

shelter into its wood. Others lay their eggs in the soft buds, producing or not producing according to their kind distorted growths known as "galls" (one plant is known to have as many as thirty species of gall-flies which make use of it). Other insects lay their eggs in the flower-buds and immature fruits, or place them on the plant so that the young grubs, when hatched, can at once eat into those soft parts. Others bore into the wood or into hard or fleshy fruits expressly to lay their eggs, or into the ripe seeds. Certain ants live in chambers specially provided by the woody parts of the plant for them, and benefit both themselves and the plant by devouring other insects which seek the plant in order to devour it. In a museum of natural history there should be exhibited at least one plant with specimens and enlarged models of all the insects which depend upon it for food, protection, or nursery, and with accompanying illustrations of the way in which those purposes are served.

A curious product of the relationship of an insect and a plant is the so-called "jumping bean," which is brought to this country from Mexico, and may be purchased in some of the London shops which deal in "miscellaneous" articles. They have been known for some years, but are becoming now a regular article of commerce. As one buys them (Fig. 16) they are segments of a globular fruit which has divided into three, comparable to the familiar segments of an orange, but less numerous. They are about one-third of an inch long, light, quite dry, and apparently hollow, without any visible opening. Two sides of the little capsule are flat, and the third side is bulged and rounded, so that the capsule easily rocks when resting on that side. When these dry fruits or segments of a fruit are brought into a warm room or placed near a fire so as to make them as warm as the hand, they commence to rock and move with curious little jerks. They jump as much as one-eighth of an inch from the ground, and advance as much as a quarter of an inch at a time, though by rolling they may progress a good deal more. They will often

move seven or eight times in the same direction so as to make a progress of a couple of inches on a flat surface, and I have found that if a cool surface or protection from warmth is within reach they will in the course of time arrive at that cool area and come to rest. When the plate on which they are placed becomes cool or the temperature of the room falls to what we should call "chilly," they cease to move, but can be roused again by renewed warmth.

FIG. 16.—On the right two jumping beans; on the left the caterpillar removed from a jumping bean. The figures are a little larger than life-size, as is shown by the line drawn near the caterpillar giving its actual length. The shape of the "beans," as segments of a tripartite sphere, is seen. One shows a round hole, with a lid-like piece marked *a*, removed from the hole. This hole did not exist when the bean first came into my possession in November 1908. At that time the caterpillar within was active, and the bean or fruit-segment often jumped. In April the caterpillar cut this round hole from within, leaving the circular lid in place, and became a chrysalis. The lid was pushed out, as shown in the drawing, by the moth when it escaped from the chrysalis in July. (Drawn from nature.)

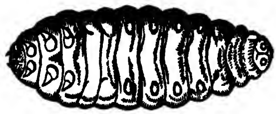


FIG. 17.—The caterpillar of the moth, *Carpocapsa saltitans*, removed from the jumping bean: magnified three diameters. Observe the jaws (with which the circular plate is cut in the bean before the grub becomes a chrysalis), eyes, three pairs of pointed legs, four sucker legs placed in the middle region, and followed by three segments without legs, and a terminal segment with a pair of suckers. (Drawn from nature for this work.)

How and why do these "beans," or, rather, fruit-segments (for they are not beans), move in this determined purposeful manner? The whole proceeding has a mysterious and uncanny aspect. They have no legs, no spring; they are simple little smooth capsules, and yet they jump and seemingly "walk" about. The explanation is that there is a grub inside each so-called "bean." Cut one of the beans or capsules open, and you find that it is a very thin-walled and hollow case, but coiled on itself in the cavity you open, and about half filling it, is a yellowish white grub (Figs. 16 and 17). It is not a "maggot," but a "caterpillar," that is to say, it is not legless, but has eight pairs of legs—namely, three pairs of short walking legs in

front, four pairs of sucker-like legs, and a hinder pair of larger size called "claspers." It has a hard brown plate on its head, and possesses hard jaws. It refuses to leave the opened capsule, and crawls back again if forcibly removed, and in the course of a few hours spins a silken cover to replace the piece of "shell" you have cut away. Mr. Rollo has lately succeeded in getting the caterpillar to patch up its injured residence with a thin piece of glass, such as is used by microscopists, which he put in place of a side of the capsule removed by a knife. He was thus able subsequently to watch through the glass the movements of the little creature when it causes the mended capsule or "bean" to jump. It rears itself from the lower surface of the capsule, and gives a series of sharp blows to the roof, projecting its body with each blow, and thus overbalances the capsule, or, if the flat side is lying downwards, jerks it along much as one may sit with one's feet on the rail of a chair and cause it to jerk along the floor by the swinging movements of the body. The caterpillar does not die at once when removed from the capsule; it has been kept alive in a glass tube for a month.

So far so good. The next questions are: What Mexican plant is it that forms the capsule or tripartite fruit in which the caterpillar is found? How did the caterpillar get there? What kind of an insect does it turn into, and when? I will answer the last question first. The caterpillar turns into a chrysalis in the early part of the year, having first cut a perfectly circular ring in the shell of the capsule. The circular plate thus within the ring is not disturbed, and cannot be observed without very close inspection. The making of this perfectly circular cut without removing the piece marked out must be effected by a rotation of the caterpillar's head and jaws as a centre-bit —an astonishing performance. But when the moth emerges from the chrysalis, a gentle push is enough to cause the little circular plate to fall out, and the moth creeps through the hole to the outer world. The moth, which comes out of the chrysalis-coat, is a very pretty little

creature (see Fig. 18), measuring two-thirds of an inch across the opened wings, which are marked with dark and reddish-brown-coloured bands. It is a close ally of the British codling moth, the caterpillar of which eats its way into the core of apples, and is familiar to all growers and eaters of that fruit. The codling moth and the Mexican "jumper" belong to a group of small moths called *Tortricinæ*, and they are named respectively *Carpocapsa saltitans* (the one whose grub or caterpillar inhabits the "jumping bean") and *Carpocapsa pomonana*, the codling moth. There are other British species of *Carpocapsa*, the grubs of which eat into the acorn, the walnut, the chestnut, and the beechnut—a distinct kind of species for each. None of these grubs cause the nuts they attack to "jump."

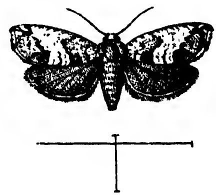


FIG. 18.—The moth, *Carpocapsa saltitans*, which escapes from the jumping bean or segment of the fruit of the Mexican spurge, *Sebastiana palmeri*, in which its caterpillar and chrysalis have passed their lives. The crossed lines indicate the natural size of the moth. (Drawn from nature.)

The "jumping bean" of Mexico is a segment of the triply divided fruit of a large spurge, which is called *Sebastiana palmeri*. The spurges are known in England as little green-leaved annuals, with yellow-green flowers and a milky juice. Botanists call them the *Euphorbiaceæ*, and in that "natural order" are included the boxwood tree and some tropical trees of great value and importance. None other than the Brazilian india-rubber tree, Hevea, of which we hear so much nowadays, its rubber to the value of £14,000,000 being exported every year from Brazil, is one of them. So also is the Chinese candle-tree, which furnishes a tallow-like fat, made into candles in China. Others are the croton oil and the castor oil shrubs, natives of India, and the manihot or tapioca plant. The fruit of *Sebastiana* (the jumping bean) are very much like those of the croton; and as there are crotons (though not the one

of the purgative oil) in abundance in Mexico, it has taken some time to make sure that the "Jumping bean" is not the fruit of a croton, but that of the allied plant *Sebastiana*. It appears that there is no commercial value for this plant, and that those capsules which happen to contain a grub and move are collected from the ground by the native Mexican boys and sold as curiosities.

The moth (*Carpocapsa saltitans*) lays its eggs on the Sebastian shrub, and the young grub, on hatching, eats its way into the young fruit when the latter is still quite soft and the seed unformed, and so leaves no hole to mark its entrance. As the fruit swells the grub eats out the seed and surrounding pulp of the segment of the fruit into which it entered early in life. By the time the fruits are dry and fall to the ground the caterpillar is fully grown. Of course, it is only a very few of the capsules which are thus invaded by a grub.

The question very naturally arises, "Why should the caterpillar put itself to the great muscular effort of making the little capsule in which it is contained jump and move over the ground?" It seems probable that these movements are made in order to bring the capsule from an exposed position when it falls on to the ground—where it might be crushed or eaten by some animal—into a position of shelter, either into a hole, or under some stone or fallen wood. The warmth of the sun in an exposed position excites the caterpillar to activity, which ceases when it has reached the shade offered by some protecting cranny. In the same way I have applied artificial heat, and alternatively, shelter from heat, so as to cause the movements or the resting of the jumping bean in a London sitting-room.

These things and others of absorbing interest may be seen in the truly wonderful museum of Kew Gardens, where perhaps the visitor will be disposed to spend more time in cold weather than in the summer. The park at Kew Gardens, with its splendid forest and lakes, and its Italian tower, is one of the beautiful things of England,

and it has a special quality even in this season of mist and veiled sunshine. I found there recently, under the trees, as I did fifty years ago, a rare and strange-looking fungus, the *Phallus impudicus* of botanists,—a furtive denizen of the glades which in late spring are purple with wild hyacinths. The same spot in June presents within a few minutes' journey from the smoke and smell and noise of Piccadilly a perfect sample of what is, perhaps, the most beautiful sight in Nature—bright sunlight breaking through the young green leaves of a forest on to green herbage. And close by are the azaleas!

NEW YEAR'S DAY AND THE CALENDAR

I CAME across a discussion the other day as to whether it is right to tell children and to let them believe that Santa Claus puts Christmas presents in their stockings, and that Peter Pan really comes in at the window and teaches nice little boys and girls to float through the air. I was surprised that anyone should be so singularly ignorant of child-nature as to hold that children really believe these things. Children have a wonderful and special faculty of " make-believe " which is not the same as " belief." All the time when a child is indulging in " make-believe " (a sort of willing self-illusion or waking dream) its real, though tender, reasoning-power is merely " suspended," and is not offended or outraged. That power can on emergency be brought to the front, and the little one will say, " Of course, they're not real," or, " I always knew he didn't really come down the chimney." So that I do not think anyone need be anxious as to doing harm or laying the foundations of future distrust by telling fairy-tales to the very young. If told in the right form and spirit they are received by six-year-old and older children readily and naturally as belonging to that delicious world of " make-believe " which (as one of their own orators, I believe, has said) " children of even the meanest intelligence will not be guilty of confounding with that very inferior every-day world of reality in which we find, much to our regret, that it is necessary to spend so large a part of our time." The power of make-believe is almost limitless, and makes its appearance even in the speechless infant of less than two years old, who will gather fruit from a coloured picture, generously offer you a bit, and pretend to swallow the rest itself. Make-believe must have been a very big factor in the life of the ape-like predecessors of prehistoric man.

Deception in the world of reality is very different from

make-believe, and a terrible thing. To the child—deception in regard to real things, whatever excuses adults may put forward in its defence, is wellnigh unforgivable. To be one who never says "it is" when it is not, nor "it will be" when it will not be—that is to be a friend on whom a child rests in perfect trust and happiness.

What have these thoughts to do with the New Year? Merely this, that it is not only with and for children that we make-believe at this season—we all of us, more or less, indulge in a make-believe about the New Year. As the clock strikes its twelve notes at midnight on December 31st, and all the bells of a great city are heard hovering in the air, sending forth their sweet sounds from far and near into the fateful night, there are few of us who have not a feeling that a great event has occurred. A physical change has set in—the Old Year is dead and gone, and the New year, something tangible, which you can let in at the door or the window—has just come into being, and is there waiting for us. We are, of course, indulging in "make-believe," for there is no New Year, with any natural, noteworthy thing to mark its commencement, starting at midnight on December 31st. New Years begin every day and hour, and it is by no means agreed upon by all nations of the earth to pretend that the 1st of January is the critical day which we must regard as that portentous epoch, the beginning of the New Year. This choice of a day was made by the Romans, and that wonderful man Julius Caesar had a great deal to do with it; modern Europe adopted his arrangement of the year or calendar. But the Jews have their own calendar and their own New Year's Day, which varies from year to year from our September 5th to our October 7th. It is, however, to them always the first day of the month Tishri, and the first day of their new year. The Mahomedans took the date of the flight of Mohammed from Mecca to Medina—the night of July 15th, A.D. 622—as the commencement of their "era," and its anniversary is the first day of their month Muharram and the first day of their year—their New Year's Day. As, although

they reckon twelve months to the year, their months are true lunar months, and are not corrected as are those in use by us (as I will explain below), their year consists of 354 days 8 hours, and so does not run parallel to our year at all. Their New Year's Day, which began by being our July 16th, was in the next year coincident with our July 6th, then in three successive years it occurred on different days of June, and so on through May, April, and the preceding months, so that in thirty-two and a half of our years their New Year's Day has run through all our months and comes back again to July.

So much for New Year's Days; they are arbitrary selections, and though the Roman New Year's Day, or January 1st, has been precisely defined and fixed by the determination by astronomers of the position of the earth on that day in its revolution around the sun, yet the original selection of January 1st for the beginning of the year seems to have been merely the result of previous errors and negligence in attempting to fix the winter solstice (which now comes out as December 22nd). This is the day when the sun is lowest and the day shortest; after it has passed the sun appears gradually to acquire a new power, and increases the duration of his stay above the horizon until the longest day is reached—the summer solstice (June 21st). Julius Caesar took January 1st for New Year's Day as being the first day of a month nearest to the winter solstice. The ancient Greeks regarded the beginning of September as "New Year."

Were mankind content with the measure of time by the completion of a cycle of revolution of the earth around the sun—that is the year—and by the revolution of the earth on its own axis—that is the day or day-night (νυχθημέρον) of the Greeks—the notation of time and of seasons would be comparatively simple. No one seems to know why or when the day was first divided into twenty-four hours nor why sixty minutes were taken in the hour and sixty seconds in the minute. The ancient astronomers of Egypt and China, and their beliefs in mystical numbers, have to

do with the first choosing of these intervals in unrecorded ages of antiquity (as much as 2000 or 3000 B.C.). The seven days of the week correspond to the five planets known to the ancients, with the addition of the sun and the moon. But the Greeks made three weeks of ten days each in a month. The true year—the exact period of a complete revolution of the earth around the sun—is 365 days 5 hours 18 minutes and 46 seconds. It was measured with a fair amount of accuracy by very ancient races of men, who fixed the position of the rising sun at the longest day by erecting big stones, one close at hand and one at a distance, so as to give a line pointing exactly to the rising spot of the sun on the horizon, as at Stonehenge. They recorded the number of days which elapsed before the longest day again appeared, and they marked also the division of that period by the two events of equally long sunlight and darkness—the spring and the autumn "equinox." It is obvious that if they took 365 days roughly as the period of revolution they would (owing to the odd hours and minutes left out) get about a day wrong in four years, and it was the business of the priests—even in ancient Rome the pontiffs were charged with this duty—to make the correction, add the missing day, and proclaim the chief days of the year—the shortest day, the longest day, and the equinox-days of equal halves of sunshine and darkness. In ancient China, if the State astronomer made a wrong calculation in predicting an eclipse he was decapitated.

It is easy to understand how it became desirable to recognize more convenient divisions of the year than the four quarters marked by the solstices and the equinoxes. Various astronomical events were studied, and their regular recurrence ascertained, and they were used for this purpose. But the most obvious natural timekeeper to make use of, besides the sun, was the moon. The moon completes its cycle of change on the average in 29½ days. It was used by every man to mark the passage of the year, and its periods from new moon to new moon were called as in our language, "months" or "moons," and divided

into quarters. It is, however, an awkward fact that twelve lunar months give 354 days, so that there are eleven days left over when the solar year is divided into lunar months. The attempt to invent and cause the adoption of a system which shall regularly mark out the year into the popular and universally recognized " moons," and yet shall not make the year itself, so built up, of a length which does not agree with the true year recorded by the return of the rising sun to exactly the same spot on the horizon after 365 days and a few hours, has been throughout all the history of civilized man, and even among prehistoric peoples, a matter of difficulty. It has led to the most varied and ingenious systems entrusted to the most learned priests and state officers, and mostly so complicated as to break down in the working, until we come to the great clear-headed man Julius Caesar.

In the very earliest times of the city of Rome the solar year, or complete cycle of the seasons, was divided into ten lunar months covering 304 days, and it is not known how the remaining days necessary to complete the solar revolution were dealt with, or disposed of. The year was considered to commence with March, probably with the intention of getting New Year's Day near to the spring equinox. The Celtic people and the Druids, with their mistletoe rites, kept New Year also at that time. The ten Roman months were named Martius, Aprilus, Maius, Junius, Quintilis, Sextilis, September, October, November, December. In the reign of the King Numa two months were added to the year—namely, Januarius at the beginning and Februarius at the end. In 452 B.C. February was removed from the end and given second place. The Romans thus arranged twelve months into the year, as the ancient Egyptians and the Greeks had long before done. The months were made by law to consist alternately of twenty-nine and of thirty days (thus keeping near to the average length of a true lunar cycle), and an odd day was thrown in for luck, making the year to consist of 355 days. This, of course, differs from the solar year by ten

days and a bit. To make the solar year and the civil or calendar year coincide as nearly as might be Numa ordered that a special or "intercalary" month should be inserted every second year between February 23rd and 24th. It was called "Mercedonius," and consisted of twenty-two and of twenty-three days alternately, so that four years contained 1465 days, giving a mean of 366¼ days to each year. But this gave nearly a day too much in each year of the calendar (as the legal or civil year is called) as compared with the true solar year, agreement with which was the object in view. So another law was made to reduce the excess of days in every twenty-four years. Obviously the superintendence of these variations, and the public declaration of the calendar for each year, was a very serious and important task, affecting all kinds of legal contracts. The pontiffs to whom the duty was assigned abused their power for political ends, and so little care had they taken to regulate the civil year and keep it in coincidence with the solar year that in the time of Julius Caesar the civil equinox differed from the astronomical by three months, the real spring equinox occurring, not at the end of what was called March by the calendar, but in June!

Julius Caesar took the matter in hand and put things into better order. He abolished all attempt to record by the calendar a lunar year of twelve lunar months; he fixed the length of the civil year to agree as near as might be with that of the solar year, and arbitrarily altered the months; in fact, abandoned the "lunar month" and instituted the "calendar month." Thus he decreed that the ordinary year should be 365 days, but that every fourth year (which, for some perverse reason, we call "leap" year) should have an extra day. He ordered that the alternate months, from January to November inclusive, should have thirty-one days and the others thirty days, excepting February, which was to have in common years twenty-nine, but in every fourth year (our leap year) thirty. This perfectly reasonable, though arbitrary, definition of the months was accompanied by the alteration

of the name of the month Quintilis to Julius, in honour of the great man Later Augustus had the name of the month Sextilis altered to Augustus for his own glorification, and in order to gratify his vanity a law was passed taking away a day from February and putting it on to August, so that August might have thirty-one days as well as July, and not the inferior total of thirty previously assigned to it! At the same time, so that three months of thirty-one days might not come together, September and November were reduced to thirty days, and thirty-one given to October and December. In order to get everything into order and start fair Julius Caesar restored the spring equinox to March 25th (Numa's date for it, but really four days late). For this purpose he ordered two extraordinary months, as well as Numa's intercalary month Mercedonius, to be inserted in the year 47 B.C., giving that year in all 445 days. It was called "the last year of confusion." January 1st, forty-six years before the birth of Christ and the 708th since the foundation of the city, was the first day of "the first Julian year."

Although Julius Caesar's correction and his provisions for keeping the "civil" year coincident with the astronomical year were admirable, yet they were not perfect. His astronomer, by name Sosigenes, did his best, but assumed the astronomical year to be 11 min. 14 sec. longer than it really is. In 400 years this amounts to an error of three days. The increasing disagreement of the "civil" and the "real" equinox was noticed by learned men in successive centuries. At last, in A.D. 1582, it was found that the real astronomical equinox, which was supposed to occur on March 25th, when Julius Caesar introduced his calendar (not on March 21st, as was later discovered to be the fact), had retrograded towards the beginning of the civil year, so that it coincided with March 11th of the calendar. In order to restore the equinox to its proper place (March 21st), Pope Gregory XIII directed ten days to be suppressed in the calendar—of that year—and to prevent things going wrong again it was enacted that leap-year day

shall not be reckoned in those centenary years which are not multiples of 400. Thus Pope Gregory got rid of three days out of the Julian calendar, or civil year, in every 400 years, since 1600 was retained as a leap year, but 1700 1800 and 1900, though according to the former law leap years, were made common years, whilst 2000 will be a leap year. In order to correct a further minute error, namely, the fact that the calendar year as now amended is 26 sec. longer than the true solar year, it is proposed that the year 4000 and all its multiples shall be common years, and not leap years. This is a matter which, though practical, is of distinctly remote importance. Some people like to look well ahead.

The alteration in the calendar made by Pope Gregory was successfully opposed for a long time in Great Britain by popular prejudice. It was called "new style," and was at last accepted, as in other European countries, but has never been adopted in Russia, which retains the "old style." An Act of Parliament was passed in 1751 ordering that the day following September 2nd, 1752, should be accounted the fourteenth of that month. Many people thought that they had been cheated out of eleven days of life, and there were serious riots! The change had been already made in Scotland in the year 1600 without much outcry. The Scotch were either too "canny" or too dull to "fash" themselves about it.

Let us now revert for a moment to the proceedings of Oriental potentates in regard to astronomers, a class of scientific functionaries whom they have from remote ages been in the habit of employing. It appears that in China there is no attempt to make the civil year or year of the calendar coincide with the astronomical year. The astronomical year is reckoned as beginning when the sun enters Capricorn, our winter solstice, and is thus more reasonably defined than is the commencement of our New Year, which is nine days late. Twelve months are recognized; the first is called Tzu, the second Chou, and the third Yin, and the rest respectively Mao, Chen, Su, Wu, Wei, Shen, Yu,

Hsu, Hai. But the calendar year, on the other hand, begins just when the Emperor chooses to say it shall. He is like the captain of a ship, who says of the hour, "Make it so," and it is so. With great ceremony he issues a calendar ten months in advance, fixing as he pleases all the important festive and lucky days of the year. Various emperors have made New Year's Day in the fourth, third, second, first, or twelfth month. It has now been fixed for many centuries in the second astronomical month. I have mentioned above that the ancient Greeks reckoned the New Year as beginning about the end of September. But the reckoning differed in the different States, and so did the names of the months. Although the Greek astronomers determined the real solar year with remarkable accuracy, and proposed very clever modes of correcting the calendar so as to use the lunar months in reckoning, there was no general system adopted, no agreement among the "home-ruling" States.

I have stated above that the official Chinese astronomers sometimes get their heads cut off for not correctly foretelling an eclipse. Illustrating this there is the following story of a visit paid about forty years ago to the Observatory in Greenwich Park by the Shah of Persia of that date. The Persians have many close links with the Chinese, and share their views of astronomy as a sort of State function, in which the Emperor has special authority. The Shah accordingly made a great point of visiting the British State observatory, in company with King Edward, who was then Prince of Wales. Sir George Airy was the Astronomer Royal, and showed the party over the building and gave them peeps through telescopes. "Now show me an eclipse of the sun," said the Shah, speaking in French. Sir George pretended not to hear, and led the way to another instrument. "Dog of an astronomer," said the Shah, "produce me an eclipse!" Sir George politely said he had not got one and could not oblige the King of Kings. "Ho, ho!" said the Shah, turning in great indignation to the Prince of Wales. "You hear!

cut his head off!" Sir George's life was, as a matter of fact, spared, but in the course of a year he retired, and was succeeded by another Astronomer Royal. On his appointment that gentleman was astonished at receiving a letter of congratulation from the Shah of Persia. The Shah evidently thought that his blood-thirsty request had been attended to, though with some delay. He proceeded to tell the new Astronomer Royal that he had a few days before writing witnessed a total eclipse of the sun in the observatory at Teheran. This was perfectly correct. The suggestion was that the Teheran astronomers knew their business, and had the good sense to arrange an eclipse when a Royal visitor wished for one, and so escape decapitation—a course which the kindly Shah evidently wished to indicate to the new and young Astronomer Royal as that which he should pursue in order to avoid the fate of his unhappy and obstinate predecessor. The attitude of the Shah towards science is one which is not altogether unknown in this country.

THE STORY OF THE COMMON EEL

THOUGH the Scotch Highlanders are said to have a profound objection to eating eels on account of the resemblance of these fish to snakes (not a very good reason, since the quality and not the shape of what one eats is the important thing), yet eels have been a very popular delicacy in England in past days. Eel-pie Island, at Richmond, is known to most Londoners, and eel-pie shops were familiar in London less than a century ago. A good Thames eel is still appreciated by the few people who nowadays take some small amount of intelligent interest in what they eat. Abroad, eels are still popular. Eel-traps are still worked in the rivers. In such districts as the flat country, on the shores of the Adriatic, near Venice, millions of young eels are annually "shepherded" in lagoons and reservoirs, and reared to marketable size. The inland eel-fisheries of Denmark and Germany are carefully regulated and encouraged by the Government in those States.

The fact is that railways, ice-storage, and steam-trawling have, in conjunction, revolutionized our habits in regard to the use of fish as a daily article of diet. Freshwater fish are now almost unknown as a regular source of food in the British Islands. The splendid fish of the North Sea, the Channel, and the Atlantic coast have pushed them out of the market. Thirty-eight years ago, when I was a student in Leipzig and Vienna, "baked carp" was the only fish to be had in the dining-rooms we frequented. Once a week there were fresh haddock, for those who fancied them, in the celebrated Auerbach's Keller. Now the railway and packing in ice have brought North Sea fish to the centre of Europe, and created a taste for that excellent food. Even on the Mediterranean at Nice, I lately saw North Sea turbot, soles, and haddock lying on

the marble-slabs in the fish market side by side with the handsome but small bass, mullet, gurnards, and sea-bream of the local fishery, and the carp, pike, trout, and eels of the fresh waters of the South of France.

Nevertheless the eel—the common freshwater eel—is still valued on the Continent, as is proved by the fact that the German Imperial Government has recently sent an important official of the Fisheries Department to Gloucester in order to make extensive purchases of the "elvers," or young eels which come up the river Severn in millions at this season. The purpose of the German fisheries officials is to place many hundred thousands of these young eels in German rivers which are not so well supplied by natural immigration as is the Severn, and by so doing to increase the supply of well-grown eels hereafter in the river fisheries of North Germany.

This interesting practical attempt to increase the supply of eels in Germany will be further appreciated when I relate what has been discovered within the last twenty years as to the reproduction, migrations, and habits of the common freshwater eel. It has been known, time out of mind, that in the early months of every year millions of young eels a little over two inches in length, called "elvers" in English and "civelles" in French, come up the estuaries of the rivers of Europe in a dense body. They are so closely packed together as the narrower parts of the stream are reached, that thousands may be taken out of the water by merely dipping a bucket into the ranks of the procession. I obtained a few thousand of these "elvers" lately from the Severn and placed them on exhibition in the central court of the Natural History Museum in London. The Anglo-Saxon name "eel-fare" is given to this annual march or "swim" of the young eels from the sea to the fresh waters.

Though riverside folk have never doubted that the elvers are young eels which have been hatched from spawn deposited by parent eels in the sea, and are "running up" to feed and grow to maturity in the rivers and streams

inland, yet country folk away from the big rivers have queer notions as to the origin and breeding of eels. They catch large, plump eels a couple of feet long in stagnant ponds hundreds of miles from the sea, far from rivers, and more than a thousand feet above the sea-level. They have no notion that those eels originally "ran up" as little eels from the sea, nor that many of them make their way across wet grass and by rain-filled ditches back to the rivers and to the sea when they are seven years old. But that is now known to be the fact. Just as there are fish, like the salmon, which "run down" to the sea to feed and grow big and "run up" to breed in the small pools and rivulets far from the river's mouth, so there are other fishes, of which the eel is one, which run up to feed and grow and run down to breed—that is to say, to deposit and fertilize their eggs in the depths of the ocean.

Fishermen who work river-fisheries for eels (far more valued abroad than in England) distinguish "yellow eels" and "silver eels." We used to dintinguish also snigs and grigs, or narrow-nosed and broad-nosed eels (probably males and females). The remarkable fact, admitted by both fishermen and anatomists, was that you could not really tell male from female, nor, indeed, ever find an eel (that is, a common eel, as distinguished from the much larger and well-known conger eel) which was ripe, or, indeed, showed any signs of having either roe or milt within it. A popular legend exists that eels are produced by the "vivification" of horse-hair. Occasionally in summer a long, black, and very thin thread-worm (called *Gordius* by naturalists) suddenly appears in great numbers in rivers, and these are declared by the country-folk to be horse-hairs on their way to become eels! I remember a sudden swarm of them one summer in the upper river at Oxford. Really, they are parasitic worms which live inside insects for a part of their lives, and leave them in summer, passing into the water. Fanciful beliefs about aquatic creatures are common, because it is not very easy to get at the truth when it is not merely at the bottom of a well but at the

bottom of a river or of the deep sea! The fishermen of the east coast of Scotland, who think very highly of their own knowledge and intelligence, believe that the little white sea-acorns or rock-barnacles are the young of the limpets which live side by side with them, and are scornful of those who deny the correctness of what they consider an obvious conclusion!

A few years ago the Scandinavian naturalist, Petersen, showed that the "silver" eels are a later stage of growth of the "yellow" eels; that they acquire a silvery coat, and that the eye increases in size—as a sort of "wedding dress," just before they go down to the sea to breed. These silver eels are caught in some numbers about the Danish coast and river mouths, moving downwards; and Petersen has been able to distinguish the males from the females by finding the still incompletely formed milt and roe within the silver eels. Not only that, but one of Petersen's assistants at the Danish Biological Station has found that you can tell the age of an eel by the zones or rings shown by its scales, when examined with a microscope, just as the age of trees can be told by the annual rings of growth in the wood. Most people, even if familiar with eels, even cooks who have skinned an eel, do not know that they have scales; but they have,—very small ones. The age of other fishes has been similarly ascertained by annual zones of growth marked on the scales; and lately the age of plaice has been found to be conveniently given by zones of growth formed annually on the little ear-stones which we find in the liquid-holding sac of the internal ear. I am afraid many of my readers will be surprised to learn that fishes have an internal hearing apparatus similar to our own, also that they have olfactory organs, and, in some cases, a well-grown tongue!

The power thus obtained of telling the age of an eel has led to the following knowledge about them, namely, that female eels do not become "silver" eels and "run down" before they are seven years old, and often not till eight and a half years of age, or even sometimes eleven or

twelve years, when they are nearly 3 feet long. The male eel becomes " silver " (instead of " yellow ") at an earlier age—four and a half years—and rarely defers his nuptial outburst until he is seven or eight years old. The females of the same age are larger than the males ; a usual size for silver females of seven years old is a little over 2 feet, and of a silver male of the same age 20 inches.

The further facts which I am about to relate as to the migration and reproduction of the common eel are of great interest. The common " yellow " eels of our ponds and rivers, as we have seen, when they are from five to seven years old and over, put on, as it were, a wedding dress. They become " silver " eels, and descend the rivers to the sea. There they produce their spawn. The young eels thus produced, when only 2 inches long, leave the sea. Every year they ascend the estuaries and rivers of Europe as " elvers " in enormous numbers, their procession up the rivers being known as " the eel-fare."

Some eels, shut up in moats and ponds, never escape—they become more or less " silver " and restless, but fail to get away. Others crawl up the banks in wet, warm weather, when the ponds are full to the brim, and over the meadows. They are found sometimes on their journey when they

" . . . have to pass
Through the dewy grass,"

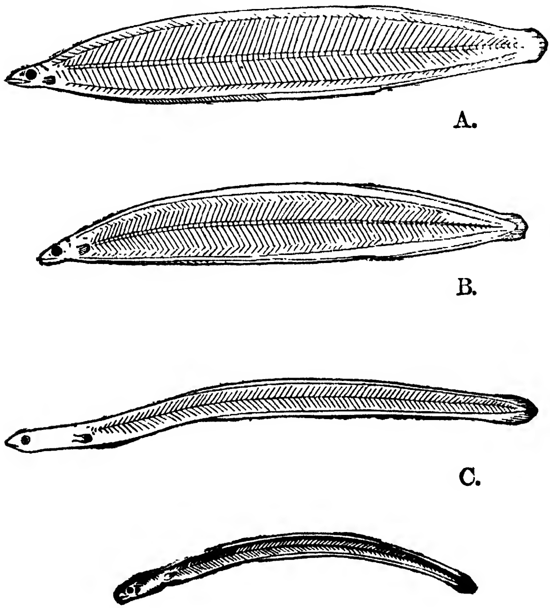
and so to the river, and on to the marriage feast in the deep sea. The fact is, that usually eels inhabit in large numbers the rivers and streams, and have no difficulty in getting down to the sea when they are adult. Those who, as young elvers, have wandered far off into sunken ponds and reservoirs, are eccentric spirits who have lost the normal way of life ; like fellows of colleges in the old days, they have cut themselves off from the matrimonial " running down," but they have compensations in quietude, abundant food, and a long life.

We now know where the silver eels go when they run

down the rivers. They go into the sea, of course; but we know more than that. It has now been discovered that they make their way for many miles along the sea-bottom—in some cases hundreds of miles—to no less a depth than 500 fathoms. In the Mediterranean they don't have very far to go, for there is very deep water near the land, and Professor Grassi found evidence of their presence in the depths of the Straits of Messina. But the eels of the rivers which empty into the North Sea and English Channel have much farther to go; they have to go right out to the deep water of the Atlantic, off the west coast of Ireland. That is the nearest point where 500 fathoms can be touched; there is no such depth in the North Sea nor in the Channel. They never come back, and no one has ever yet tracked them on their journey to the deep water. Yet we know that they go there, and lay their eggs there, and that from these remote fastnesses a new generation of eels, born in "the dark unfathomed depths of ocean," return every year in their millions as little "elvers" to the rivers from which their parents swam forth in silver wedding dress. Soon, we have reason to hope, by the use of suitable deep-sinking nets, we shall intercept, in the English Channel, some of the silver eels on their way to the Atlantic deeps. They must go in vast numbers, and yet no one has yet come across them. How, then, do we know that the silver eels ever go to this 500-fathom abysm?

The answer is as follows: A very curious, colourless, transparent, absolutely grass-like, little fish, 2½ inches long, oblong and leaf-like in shape, has been known for many years as a rarity, to be caught now and then, one at a time, floating near the top in summer seas (Fig. 19). I used to get it at Naples occasionally many years ago and it has sometimes been taken in the English Channel. It is known by the name "Leptocephalus." Placed in a glass jar full of sea water it is nearly invisible on account of its transparency and freedom from colour. Even its blood is colourless. The eyes alone are coloured, and one sees these as two isolated black globes moving mysteriously to

the right and the left as the invisible ghostly fish swims around. Twenty years ago one of these kept in an aquarium at Roscoff, in Brittany, gradually shrunk in breadth, became cylindrical, coloured and opaque, and assumed the complete characters of a young eel! To cut a long story short, these Leptocephali were found twelve



A.

B.

C.

D.

19.—Young stages of the common eel, drawn of the natural size by Professor Grassi. A, The *Leptocephalus*, transparent stage. D, the elver, or young eel, which is coloured, and of much smaller size than the transparent, colourless creature by the change of which it is produced. It is the elver which swims in millions up our rivers. B and C are intermediate stages, showing the gradual change of A into D.

years ago in large numbers in the deep water (400 fathoms) of the Straits of Messina by the Italian naturalists Grassi and Calandruccio, and they conclusively showed that they were the young phase—the tadpole, as it were—of eels. They showed that different kinds of eels—conger eels, the Muræna, and the common eel—have each their own kind

of transparent "Leptocephalus-young phase," living in but also above the very deep water, in which they are hatched from the eggs of the parent eels. The Leptocephalus young when hatched, grow rapidly, and ascend to near the surface immediately above the deep water, and are caught at depths of ten to a hundred fathoms. To become "elvers," or young eels, they have to undergo great change of shape and colour, and actually shrink in bulk—a process which has now been completely observed and described. It is not surprising that their true nature was not at first recognized. The proof that the silver eels of North and West Europe go down to the 500-fathom line off the Irish coast, in order to lay their eggs, is that the Danish naturalist Schmidt and his companions discovered there two years ago, above these great depths (and nowhere else), by employing a special kind of fine-meshed trawling net, many thousands of the flat, glass-like "Leptocephalus-young stage," or tadpole of the common eel, and traced them from there to their entrance into the various rivers. They showed that the Leptocephali gradually change on the way landward into eel-like "elvers."

The rivers nearest the deep water, such as those opening on the west coast of Ireland and on the Spanish and French shores of the Bay of Biscay, get their elvers "running up" as early as November, December, and January. The farther off the river the farther the elvers have to travel from the deep-sea nursery, so that in Denmark they don't appear until May. Not the least curious part of the migration of the eel is the passage of the young elvers into the higher parts of rivers and remote streams. They are sometimes seen a hundred miles from the sea, actually wriggling in numbers up the face of a damp rock or wall ten or fifteen feet high, pushing one another from below upwards, so as to scale the obstacle and reach higher waters, like Japanese soldiers at a fort. I found them (so long ago that I hesitate to name the date—it was a year of cholera in London, followed by a great war) in a little rivulet which comes down the cliff at Ecclesbourne,

near Hastings, close to a cottage frequented at that time by Douglas Jerrold. They were wriggling up in the damp grass and overflow of the driblet 150 feet above the shore, a stone's throw below. They must have come out of the sea, attracted by the tiny thread of fresh water entering it at this spot.

The Danube and its tributary streams contain no eels, although the rivers which open into the Mediterranean are well stocked with them. This is supposed to be due to the fact that the Black Sea does not afford a suitable breeding-ground, and that the way through the Dardanelles is closed to eels by some natural law, as it has been to warships by treaty. Probably, however, it will be found that the geological changes in the area of sea and land are intimately connected with the migrations of the eel, and that the eel is originally a marine fish which did not in remote ages travel far from the deep waters. Its gradually acquired habit of running up fresh waters to feed has led it step by step into a frequentation of certain rivers which have become (by changes of land and sea) inconveniently remote from its ancestral haunts. An interesting question is whether at the not very distant period when there was continuous land joining England to France and the Thames and the Rhine had a common mouth opening into the North Sea, eels existed in the area drained by those two rivers; and, if so, by what route did they pass as silver eels to the deep sea, and by what route did the new generations of young eels hatched in the deep sea travel to the Thames and Rhine. It seems most probable that in those days there were no eels in the Thames and other North Sea rivers.

Our present knowledge of the romantic history of the common eel of our own rivers we owe in large part to the work done by the International Committee for the Investigation of the North Sea. Who would ever have imagined when he caught a wriggling eel, with a hook and worm thrown into a stagnant pool in the Midlands that the muddy creature was some five or six years ago living as a

glass-like leaf-shaped prodigy in the Atlantic depths, a hundred miles from Ireland? Who would have dreamed that it had come all that long journey by its own efforts, and would probably, if it had not been hooked, have wriggled one summer's night out of the pond, across wet meadows, into a ditch, and so to the river, and back to the sea, and to the far-away orgy in the dark salt waters of the ocean-floor, to the consummation of its life and its strange, mysterious ending?

There are two points of interest to be mentioned in regard to the rivers Danube and Thames in connection with eels. I have trustworthy reports of the very rare occurrence of eels in streams connected with the Danube. Since the young elvers do not ascend the Danube, where do these rare specimens come from? There can be no doubt that they have made their way individually into the Danube "system" by migration through canals or ditches from tributaries of the Rhine or the Elbe. A similar explanation has to be offered of the eels which at present inhabit the Thames. I cannot find any evidence of the existence to-day of an "eel-fare"—that is, "a running up of elvers" in the river Thames. Probably about the same time as the foul poisoning of the Thames water by London sewage and chemical works put an end to the ascent of the salmon (about the year 1830), the entrance of the myriad swarm of young eels in their annual procession from the sea also ceased. The elvers were caught and made into fish-cakes in London before the nineteenth century, just as they are to-day at Gloucester. It would be interesting to know exactly when they ceased to appear in the Thames. A curious fact, however, is that young eels—not so small as "elvers," but from three inches in length upwards—are taken close above London even to-day. Four years ago I obtained a number of this small size from Teddington. The question arises as to whether these specimens represent just a small number of elvers which have managed to swim through the foul water of London and emerge into the cleaner part of the river

above. This is improbable. It is more likely that they have come into the Thames by travelling up other rivers such as the Avon—which are connected by cuttings with the Thames tributaries. But it certainly is remarkable that eels of only three inches in length—and therefore very young—should have managed to get not merely " into " the Thames (to the upper parts of which no doubt many thus travel and remain during growth), but actually " down " the Thames so far in the direction of its tidal water as is Teddington lock. The specimens from Teddington were placed by me in the Natural History Museum.

COMETS

A COMET is so called from the hair-like stream of light or "tail," which stretches to a greater or less length from its bright head or "nucleus." A large comet, when seen to greatest advantage, may have a tail which stretches across one-third of the "vault of heaven," and may be reckoned by astronomers at as much as one hundred and twenty million miles long. Donati's comet—which some of my readers will remember, as I do, when it visited us in 1858—was of this imposing size. Halley's comet, on the other hand, when it was last "here," namely, in 1835, showed a tail estimated by astronomers to be fifty million miles long. The tail was more than twice as long when Halley's comet appeared in 1456. There was a big comet "on view" in 1811—the year celebrated for its wine—and in recent times a fine comet appeared in 1861, and another (Coggia's comet) in 1874.

The ancient records of comets are naturally full of exaggeration. Up to Milton's time—two hundred and fifty years ago—they caused the greatest terror and excitement by their sudden appearance in the sky. This is due to the fact that mankind from the very earliest periods of which we have record has not merely gazed at the "starry host" by night in solemn wonder, but even in early prehistoric times studied and watched the stars so as to know much of their movements and regular comings and goings. The earliest priests, the earliest "wise men," were those who knew the stars and could fix the seasons by their place; the earliest temples—Stonehenge, and others older still—were star-temples or observatories, and their priests were astronomers. To such a pitch did reverence for star-knowledge attain that our ancestors confused the astral signs of changing season and cycle with the cause itself of change, and attributed all kinds of mundane events

and each man's fate to the "influence of the stars." Hence the sudden appearance of a flaming comet was held to be a portent, and was always supposed either to foretell or even to produce some very unpleasant event, such as a big war or a pestilence, or the death of someone supposed to be of consequence. The earliest Greek poetry enshrines the superstition, which is handed on by Virgil, and finally by Milton. In Pope's translation of the *Iliad* we find the helmet of the terrible Achilles described as shining

> "Like the red star, that from his flaming hair
> Shakes down diseases, pestilence, and war."

And Milton, in 1665, in his *Paradise Lost*, wrote—

> "On th'other side,
> Incenst with indignation, Satan stood
> Unterrifi'd; and like a comet burn'd,
> That fires the length of Ophiuchus huge
> In th' Arctic sky, and from his horrid hair
> Shakes pestilence and war."

In this year [1] of the celebration of the tercentenary of Milton's birth, it is not a little curious to find that John Milton, himself a scholar of St. Paul's School, wrote those lines when Edmund Halley, the future Astronomer Royal, had just entered the same great school, then standing in St. Paul's Churchyard, as it did when I was "one of the fishes," and used to see men hanging in the Old Bailey —I once saw five [2]—on Monday mornings as I passed on my way to school. To a Pauline it is not without significance that the return of Halley's comet is awaited within a year of Milton's tercentenary, and that the greatest astronomer and the greatest poet of their age were London boys and Paulines.

Ancient records tell of comets of gigantic size, of the shape of a sword, the head as big as the moon, and so on. There is no reason to suppose that within historic times there have been any much bigger than that of 1858.

[1] 1908. [2] The pirates of the *Flowery Land*.

Milton, in the lines above quoted, was not referring to an imaginary comet, but to one which actually did appear when he was a boy of ten (1618), in the constellation called Ophiuchus. It was of enormous size, the tail being recorded as longer even than that of 1858. It was held responsible by educated and learned men of the day for disasters. Evelyn says in his diary, " The effects of that comet, 1618, still working in the prodigious revolutions now beginning in Europe, especially in Germany." The comet of 1665 was, with equal assurance, regarded as the cause of the Great Plague of London. In that year was published the first number of the *Philosophical Transactions* of the Royal Society of London, then recently founded " for the promotion of natural knowledge." It contains an account of a paper by a learned French gentleman, M. Auzout, in which an attempt is made to predict the movements among the stars of the comet of 1664. Astronomers had long known and been able to predict the movements of the planets and the swinging of the constellations, but, as the French author observes, " all the world had been hitherto persuaded that the motions of comets were so irregular that they could not be reduced to any laws." He also hoped, by examining the movements of the comets of 1664 and 1665, to determine " the great question whether the earth moves or not." At that time the earth was " suspected " to move round the sun, but no proof of that motion had been given. M. Auzout did not succeed in his laudable attempt, simply because Newton's great discovery of the law of gravitation had not then been made.

Edmund Halley was the intimate friend and passionate admirer of Newton. He paid out of his own pocket for the publication of Newton's *Principia* by the Royal Society in 1686, the society having expended all its available funds in printing a great work on *Fishes* (which shows how at the first, as now, the society cared for the whole range of the study of Nature). Halley was able to show that comets move regularly round the sun, in obedience

to the same law of gravitation which controls the movements of the planets and of our earth itself; so that many of them are regular members of the solar system. Halley especially calculated out the form of the orbit of the comet of 1682 as an ellipse, and the time of its journey and recurrence, or "period," as it is called, which he showed to be about seventy-five or seventy-six years. He predicted its recurrence in 1758. Halley died in 1742, at the ripe age of eighty-six, having, amongst other good deeds, founded the Royal Society Club, which still dines every Thursday in the session. His comet reappeared in 1759, a few months later than he had, owing to incomplete details used in his calculations, expected; but the accuracy of his scheme of its movement was demonstrated. It duly appeared again in 1835, and it is now awaited in the spring of 1910. Halley himself had identified his comet with that of 1607 and of 1531, and lately, by the aid of records from an ancient seat of astronomical observation—actually from China—it has been traced back to the month of May in the year 240 B.C. It has caused consternation and terror times enough since then, of some of which we have record. Finally, it has become the leading instance of the triumph of scientific knowledge and accuracy over ignorance and superstition. Halley's comet caused great alarm in Rome in the year A.D. 66. A thousand years later (1066) it was seen when William the Conqueror was preparing to descend on the coast of England, and is actually represented in the Bayeux tapestry. A number of men are drawn (or rather "stitched"), with fingers pointed and eyes raised to a shape in the sky which resembles a star-fish with a large triangular-ribbed petticoat attached to it, ending in eight flames or tongues (Fig. 20.) The picture is labelled "Isti mirant[ur] stella[m]." There is now no doubt, as accurate calculations have demonstrated, that William the Conqueror's "star" was Halley's comet—a fact which must give its reappearance in 1910 an additional interest in the eyes of Englishmen.

The shape given to the representations of stars in old

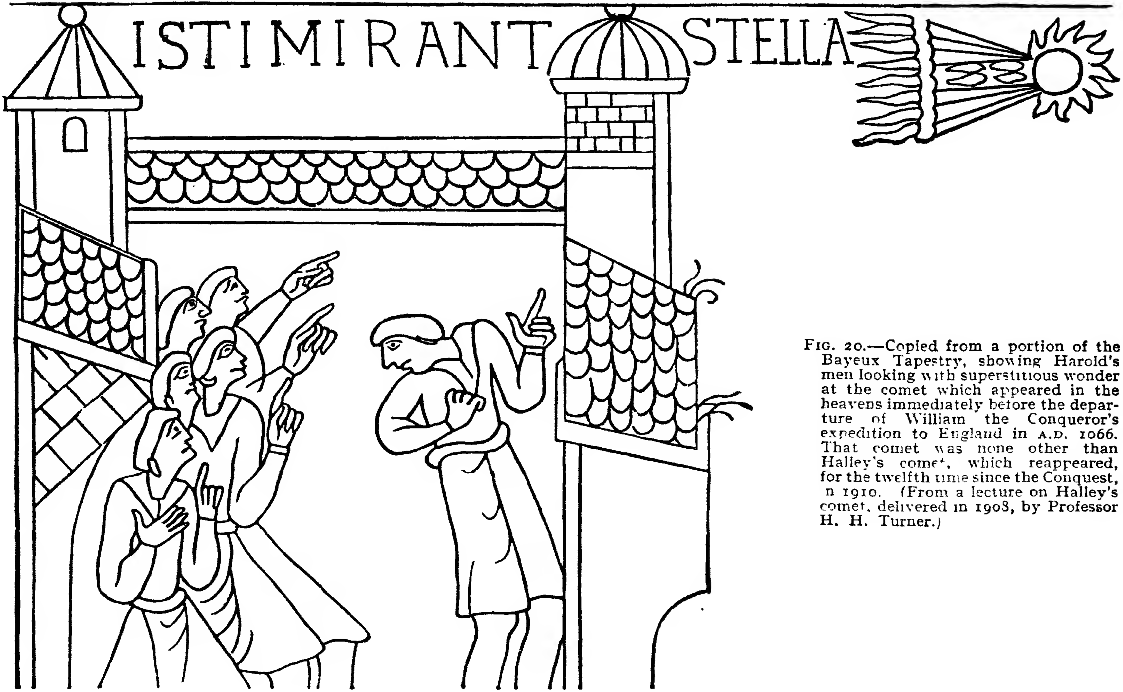


Fig. 20.—Copied from a portion of the Bayeux Tapestry, showing Harold's men looking with superstitious wonder at the comet which appeared in the heavens immediately before the departure of William the Conqueror's expedition to England in A.D. 1066. That comet was none other than Halley's comet, which reappeared, for the twelfth time since the Conquest, in 1910. (From a lecture on Halley's comet, delivered in 1908, by Professor H. H. Turner.)

pictures and engravings is a puzzle. Why do they represent a star by the shape of a star-fish? No star ever looks like that, or produces a picture of that shape on the retina. The thing is purely conventional. The shape which we call "star-shaped"—a term we apply to flowers and many other things—is not in the least like a real star as seen by an unprejudiced person. What one really sees is an ill-defined point of light. The pretended conventional star of ancient drawings perhaps arose from the simple artifice of picturing tongue-like flames around or upon any representation of a fire or a source of light—"to show what it was meant to be." Then the notions of perfection and symmetry in regard to the celestial bodies led to the "tongues" being arranged for the purposes of draughtsmanship as perfectly symmetrical-pointed rays of a six or eight-limbed geometrical design—and latterly it is possible that the mystical figure known as the "pentacle" was utilized by astrologers and others as the emblem of a star. However they arose, neither the weird and astonishing representations of mediaeval times nor the geometrical decorative "stars" of later date seem to have any relation to an attempt to represent a star as it really appears to the human eye and the interpreting brain behind it.

The orbits of comets, says Professor Turner, of Oxford, in a delightful lecture delivered in Dublin in the summer of 1908, from which I have culled many interesting facts and presented them to my readers, "differ from those of the planets in being far more highly elliptical. Our own path round the sun is nearly a circle, so that our distance from him remains nearly the same all the year round; but the distance of a comet from the sun varies greatly from 'perihelion,' when it is near, and consequently bright, to 'aphelion,' when he is so distant and faint that we lose sight of him." The sun is not at the centre of the ellipse described by a comet's path, but is quite near to one end of it, so that comets approach the sun far more closely than do the planets, some taking so close a turn round the

sun that the heat from it to which they are exposed is 2000 times as great as that which the earth receives. If the orbit of a comet is really elliptic, then there at last comes a time, though it may be only after thousands of years, when the comet, having rounded the sun at close quarters, and journeyed off into space, has his journey brought to a turning-point at the other end of the ellipse, and begins to draw near again, advancing towards the sun. The length of the orbit of Halley's comet is about 3,255 million miles, and the breadth at its broadest is about 800 million miles, and he takes about thirty-eight years to travel the full length (along the curve) and thirty-eight years to come back again! Other comets have other lengths and breadths of orbit, and take longer or shorter periods to go round. But the conditions of attraction affecting a comet may be such that the return journey never occurs. They may be such that the comet goes on indefinitely travelling away from our sun, until he is caught by some other star, and his orbit changes its shape, with the new sun as attracting centre. These are the "wand-dering comets" as distinct from the "periodic comets," which have been shown to conform to Halley's scheme of their movement and recurrence.

And now, someone will ask, perhaps impatiently, "What, after all, is a comet?" We have seen that many are continuously, and others casually, members of the solar system. What do they consist of? Spectrum-analysis shows that they consist chiefly of the chemical element carbon. Though they have weight, and are attracted by the sun, yet they seem to be for all their size and terrifying shape and glare incredibly light and airy things. Herschell declared that the tail of a big comet probably consisted of but two or three pounds of solid matter—diffused, rarefied, and luminous. And the head or nucleus certainly does not weigh many hundred tons. In the eighteenth century astronomers observed a comet pass right in among the moons of the planet Jupiter. You might expect the moons to be terribly knocked about by such an impact. They

were not; they were not deflected in the smallest appreciable degree from their position and regular movement! One is naturally inclined to look upon the tail of a comet as something like the smoke of a railway engine trailing behind the advancing "head." As a matter of fact, it does not always trail behind, but is always turned away from the sun, so that when the comet is travelling away from the sun the tail is in front! It is now held that the tail is caused by the radiant energy (light and heat) of the sun, blowing, as it were, the lighter particles from the incandescent head, and causing them to spread out in a long track of variable shape. The photographs of the third comet of the year 1908 show that the tail can vary to an astonishing extent and with great rapidity—that is to say, in four or five hours. It is seen in those photographs as a scimitar-like curved blade, then with a second head or nucleus behind the leading one, then actually bent like the letter Z, and then divided into seven distinct diverging "plumes," and then it returns to its former simple shape—all in the course of a few days. Astronomers have now shown that there is a close connection between comets and the showers of "shooting stars" or meteors which frequently strike the earth's atmosphere. It is considered probable that comets eventually break down into streams of meteors, and that their "life" (if one may use that term) is, relatively to that of other heavenly bodies (which are all undergoing change, and, in many cases, decay), not a very long one. But there are no facts at present known which enable us to tell whether a given comet is young or old, and it would have been a decided shock had it been found that Halley's comet, which has so happily spent every seventy-sixth year with us for so many centuries, had "burst up," or by "indisposition" had been unable to pay his usual visit as expected in 1910.

TOBACCO

APART from the question as to whether the smoking of tobacco is injurious to the health or not, there are many curious questions which arise from time to time as to the history and use of tobacco. I have no doubt that for children the use of tobacco is injurious, and I am inclined to think that it is only free from objection in the case of strong, healthy men, and that even they should avoid any excess, and should only smoke after meals, and never late at night. The strongest man, who can tolerate a cigar or a pipe after breakfast, lunch, and dinner, may easily get into a condition of "nerves" when even one cigarette acts as a poison and causes an injurious slowing of the heart's action.

A curious mistake, almost universally made, is that of supposing that the oily juice which forms in a pipe when tobacco is "smoked" in it, or at the narrow end of a cigar when it is consumed by "smoking," is "nicotine," the chief nerve-poison of tobacco. As a matter of fact, this juice, though it contains injurious substances, contains little or no "nicotine." Nicotine is a colourless volatile liquid, which is vaporized and carried along with the smoke; it is not deposited in the pipe or cigar-end except in very small quantity. It is the chief agent by which tobacco acts on the nervous system, and through that on the heart—the agent whose effects are sought and enjoyed by the lover of tobacco. A single drop of pure nicotine will kill a dog. Nicotine has no aroma, and has nothing to do with the flavour of tobacco, which is due to very minute quantities of special volatile bodies similar to those which give a scent to hay.

Most people are acquainted with the three ways of "taking tobacco"—that of taking its smoke into the mouth, and more or less into the lungs, that of chewing

the prepared leaf, and that of snuffing up the powdered leaf into the nose, whence it ultimately passes to the stomach. A fourth modification of the snuffing and chewing methods exists in what is called the "snuff stick." According to the novelist, Mrs. Hodgson Burnett, the country women in Kentucky use a short stick, like a brush, which they dip into a paperful of snuff; they then rub the powder on to the gums. Snuff taking has almost disappeared in "polite society" in this country within the past twenty years, but snuffing and chewing are still largely practised by those whose occupation renders it impossible or dangerous for them to carry a lighted pipe or cigar—such as sailors and fishermen and workers in many kinds of factories and engine-rooms.

One of the most curious questions in regard to the history of tobacco is that as to whether its use originated independently in Asia or was introduced there by Europeans. It is largely cultivated and used for smoking throughout the East from Turkey to China—including Persia and India on the way—and special varieties of tobacco, the Turkish, the Persian, and the Manilla are well known, and only produced in the East, whilst special forms of pipe, such as the "hukah" or "hooka," the "hubble-bubble," and the small Chinese pipe are distinctively Oriental. Not only that, but the islanders of the Far East are inveterate smokers of tobacco, and some of them have peculiar methods of obtaining the smoke, as, for instance, certain North Australians who employ "a smoke-box" made of a joint of bamboo. Smoke is blown into this receptacle by a faithful spouse, who closes its opening with her hand and presents the boxful of smoke to her husband. He inhales the smoke and hands the bamboo joint back to his wife for refilling. The Asiatic peoples are great lovers of tobacco, and it is certain that in Java they had tobacco as early as 1601, and in India in 1605. The hookah (a pipe, with water-jar attached, through which the smoke is drawn in bubbles) was seen and described by a European traveller in 1614. Should

we not, therefore, suppose that in Asia they had tobacco and practised smoking before it was introduced from America into the West of Europe? It seems unlikely that Western nations have given this luxury to the East when practically everything else of the kind has come from the East to Europe—the grape and wine made from it, the orange, lemon, peach, fig, spices of all kinds, pepper and incense. Yet it is certain that the Orientals got the habit of smoking tobacco from us, and not we from them.

Incredible as it seems, the investigations of the Swiss botanist, De Candolle, and of Colonel Sir David Prain, formerly in India, and lately Director of Kew, have rendered it quite certain that the Orientals owe tobacco and the habit of smoking entirely to the Europeans, who brought it from America as early as 1558. In the year 1560 Jean Nicot, the French Ambassador, saw the plant in Portugal, and sent seeds to France to Catherine de' Medici. It was named Nicotiana in his honour. But the introduction into Europe of the practice of smoking is chiefly due to the English. In 1586 Ralph Lane, the first Governor of Virginia, and Sir Francis Drake brought over the pipes of the North American Indians and the tobacco prepared by them. The English enthusiasm for tobacco-smoking, "drinking a pipe of tobacco," as it was at first called, was extraordinary both for its sudden development, its somewhat excessive character, and the violent antagonism which it aroused and, as we learn from Mr. Frederic Harrison, still arouses. It was called "divine tobacco" by the poet Spenser, and "our holy herb nicotian" by William Lilly (the astrologer, not the schoolmaster), and not long afterwards denounced as a devilish poison by King James. The reason why the English had most to do with the introduction of smoking is that the inhabitants of South America did not smoke pipes, but chewed the tobacco, or took it as snuff, and less frequently smoked it as a cigar. From the Isthmus of Panama as far as Canada and California, on the other hand, the custom of smoking pipes was universal. Wonderful carved pipes of great

variety were found in use by the natives of these regions, and were also dug up in very ancient burial grounds. Hence the English colonists of Virginia were the first to introduce pipe-smoking to Europe.

The Portuguese had discovered the coasts of Brazil as early as 1500, and it is they who carried tobacco to their possessions and trading ports in the Far East—to India, Java, China, and Japan, so that in less than a hundred years it was well established in those countries. Probably it went about the same time from Spain, and England to Turkey, and from there to Persia. The Eastern peoples rapidly developed not only special new forms of pipe (the hookah) for the consumption of tobacco, but also within a few years special varieties of the plant itself. These were raised by cultivation, and have formerly been erroneously regarded as native Asiatic species of tobacco plant.

The definite proof of the fact that tobacco was in this way introduced from Western Europe to the Oriental nations is, first, that Asiatics have no word for it excepting a corruption of the original American name tabaco, tobacco, or tambuco: it is certain that it is not mentioned in Chinese writings nor represented in their pottery before the year 1680. In the next place, it appears that careful examinations of old herbariums and of the records of early travellers who knew plants well and recorded all they saw, proves that no species of tobacco is a native of Asia. There are fifty species of tobacco, but all are American excepting the Nicotiana suaveolens, which is a native of the Australian continent, and the Nicotiana fragrans, which is a native of the Isle of Pines, near New Caledonia.

Forty-eight different species of tobacco (that is to say, of the genus Nicotiana) are found in America. Of these, Nicotiana tabacum is the only one which has been extensively cultivated. It has been found wild in the State of Ecuador, but was cultivated by the natives both of North and South America before the advent of Europeans. It seems probable that all the tobaccos grown in the Old

World for smoking or snuffing are only cultivated varieties—often with very special qualities—of the N. tabacum, with the exception of the Shiraz tobacco plant, which, though called N. persica, is of Brazilian origin, and the N. rustica, of Linnæus, a native of Mexico, which has a yellow flower, and yields a coarse kind of tobacco. This has been cultivated in South America and also in Asia Minor. But tobaccos so different as the Havana, the Maryland and Virginian, the incomparable Latakia, the Manilla, and the Roumelian or Turkish—all come from culture-varieties of the one great species, N. tabacum.

The treatment of tobacco-leaf to prepare it for use in smoking, snuffing, and chewing requires great skill and care, and is directed by the tradition and experience of centuries. As is the case with "hay," the dried tobacco-leaf undergoes a kind of fermentation, and, in fact, more than one such change. The cause of the fermentation is a micro-organism which multiplies in the dead leaf and causes chemical changes, just as the yeast organism grows in "wort" and changes it to "beer." It is said that the flavour and aroma of special tobaccos is due to special kinds of ferment, and that by introducing the Havana ferment or micro-organism to tobacco-leaves grown away from Cuba, you can give them much of the character of Havana tobacco! A very valuable kind of tobacco is the Roumelian, from which the best Turkish cigarettes are made. It has a very delicate flavour, and very small quantities of an aromatic kind prepared from a distinct variety of tobacco plant grown near Ephesus and on the Black Sea (probably a cultivated variety of N. rustica) are judiciously blended with it. This blending, and the use of the very finest qualities of tobacco-leaf, are essential points in the production of the best Turkish cigarettes. The so-called "Egyptian" cigarettes are made from less valuable Turkish tobacco, with the addition of an excess of the aromatic kind. It is a mistake to suppose that opium or other matters are used to adulterate tobacco. The only proceeding of the kind which occurs is the mixing

of inferior, cheap, and coarse-flavoured tobaccos with better kinds. Water and also starch are used fraudulently to increase the weight of leaf-tobacco. But skilful "blending" is a legitimate and most important feature in the manufacture of cigars, cigarettes, and smoking mixtures.

The first "smoking" of tobacco seen by Europeans was that of the Caribs or Indians of San Domingo. They used a very curious sort of tubular pipe, shaped like the letter Y. The diverging arms were placed one up each nostril, and the end of the stem held in the smoke of burning tobacco-leaves, which was thus "sniffed up" into the nose. The North American Indians, on the other hand, had pipes very similar to those still in use. The natives of South America smoked the rolled leaf (cigars), chewed it, and took it as snuff.

It has been suggested that, in Asia, smoking of some kind of dried herbs may have been a habit before tobacco was introduced—since even Herodotus states that the Scythians were accustomed to inhale the smoke of burning weeds, and showed their enjoyment of it by howling like dogs! But investigation does not support the view that anything corresponding to individual or personal "smoking" existed. "Bang" or "hashish" (the Indian hemp) was not "smoked," but swallowed as a kind of paste before the introduction of tobacco-smoking in the East—as we may gather from the stories of the *Arabian Nights*—although the practice of smoking hemp (which is the chief constituent of "bang") and also of smoking the narcotic herb "henbane," has now been established. Opium was, and is, eaten in India, not "smoked." The "smoking" of opium is a Chinese invention of the eighteenth century.

The Oriental hookah suggests a history anterior to the use of tobacco, but nothing is known of it. The word signifies a coco-nut shell, and is applied to the jar (sometimes actually a coco-nut) containing perfumed water, through which smoke from a pipe, fixed so as to dip into

the water, is drawn by a long tube with mouthpiece. It seems possible that this apparatus was in use for inhaling perfume by means of bubbles of air drawn through rose-water or such liquids, before tobacco-smoking was introduced, and that the tobacco-pipe and the perfume-jar were then combined. But travellers before the year 1600 do not mention the existence of the hookah in Persia or in India, though as soon as tobacco came into use this apparatus is described by Floris, in 1614, and by Olearius, in 1633, and by all subsequent travellers.

The conclusion to which careful inquiry has led is that though various Asiatic races have appreciated the smoke of various herbs and enjoyed inhaling it from time immemorial, yet there was no definite "smoking" in earlier times. No pipes or rolled-up packets of dried leaves—to be placed in the mouth and sucked whilst slowly burning—were in use before the introduction of tobacco by Europeans, who brought the tobacco-plant from America and the mode of enjoying its smoke, and passed on its seeds to the peoples of Turkey, Persia, India, China, and Japan.

STONE AND WOOD BORERS

BORING into wood is a favourite proceeding on the part of many small creatures, insects, shrimps, and ship-worms, by which they not only acquire nourishment, but at the same time penetrate more and more deeply into safe quarters and concealment. It is not surprising that it has become the necessary and regular mode of life of a host of small animals, and consequently that man who wants wood in good sound blocks and planks for his various constructions is a good deal put out by the voracity of the wood-boring community. To some extent he has given up the task of checking their proceedings, and now uses metal where he formerly used wood, but that only applies to a limited field. Wood is still the great material of rough construction, and the main substance used in fittings and furniture.

In our own country and in most parts of the world there are large grubs or caterpillars, such as those of the goat moth, three inches long and as thick as one's finger, which eat into the stems of trees and spoil the timber. The grub of the handsome moth known as the wood leopard is another of these. It attacks poplar trees, and we used to take it in numbers in the London parks and squares when I was a collector. The goat moth is specially destructive to willow trees. But there are a very large series of smaller grubs and adult insects which injure trees or bore or devour wood already cut and dried. Among these are the saw-flies and a number of beetles, and in Sicily and the tropics there are the wonderful white ants which are not ants at all, but more like may-flies. The destruction caused by these borers and eaters of wood is increased by the fact that when they have riddled a piece of wood, moisture penetrates it, and vegetable " moulds " flourish within it and complete the break-up. Among the

most destructive borers of wood are those which attack the ships and piers of wood placed by man in the sea. These are certain shell-fish, called ship-worms (*Teredo*), which are really peculiarly modified mussels. There is also a tiny shrimp-like creature, the *Limnoria terebrans*, which does enormous damage by its borings to piers of wood erected in the sea. True insects do not flourish in the sea. There are marine bivalve shell-fish which bore into clay, sandstone, chalk, and even into hard granite-like rock. They do not use jaws or teeth for this purpose, but the surface of their shells, which are sharp and spiny, and also the sand which adheres to their soft muscular bodies like emery powder to the pewter-plate of a lapidary's wheel. You may see the large and small holes made by *Pholas* (called also "the piddock") and other bivalve shell-fish in the clay and chalk rocks of the seashore on most parts of the English coast.

Most boring animals swallow the material which they excavate in the act of boring, just as the earth-worm swallows the soil into which it bores, and as many sand-worms do, throwing out from the hind end of the body, in the form of a little coiled-up heap, a vast quantity of undigested matter which has passed through them. But many insects which swallow some of the material disengaged by their jaws remove, in addition, a large quantity which is ejected from the boring as powder, like sawdust, and others do not swallow any of the material into which they bore. So, too, the *Pholas* and marine-boring mussels do not swallow the material which they loosen. It is a very slow process, the boring in rock, and the fine particles rubbed away by incessant movement are carried off in the sea water.

To some extent the marine creatures which bore in rocks seem to be helped by chemical action, since they show a preference for chalk and limestone, easily dissolved by weak acid secreted by the borer, though, clearly enough, they are not dependent on such chemical aid since we find them also boring in insoluble granite rock and shale

and clay. There is one true worm-borer which perforates hard limestone pebbles and chalk rocks, so as to give them the appearance which we call "worm-eaten" when caused by another sort of worm and observed in a very different material, namely, old furniture and woodwork. At Tenby, in South Wales, the limestone pebbles on the beach are quite commonly riddled with these worm-holes, truly "worm-eaten." When they are not too abundant one can see that the holes are arranged in pairs like a figure 8, about half the size here printed. On splitting the rock or stone one finds a deeply-running U-shaped double tube excavated in the stone. In this the little worm lived. It is easiest to get at the worms in a fresh and living state on a coast where there are chalk-rocks and sea-washed lumps of chalk. The chalk is easy to split and cut at low tide, and then the little key-hole apertures can be broken across and the soft red worm extracted. It is a beautiful red-blooded little worm—little more than half an inch long—with two tactile horns on its head and little bristles and gills on the rings of its annulated body. It is a true "worm," like the earth-worm, what naturalists call by the not displeasing name an "annelid." It seems at first sight impossible that this delicate little thing should "worm-eat" the hardest limestone. It has no jaws, but one of the rings or segments of the front part of the body has two of its bristles swollen to relatively gigantic size, hard and black. These are its boring organs, but I have no doubt that it is helped, especially in its young state when commencing to bore, by an acid secretion from the surface of the body.

Curiously enough, in the strict sense of the word "worm," the boring of chalk and stones by the little marine creature just mentioned (whose name is *Polydora*) is the only instance of a "worm-eaten" condition being produced by a real worm. The worm-eaten condition of wood is produced either by the grub of a minute beetle (which is not in the strict sense a "worm") or by an ingenious human maker of "antiques" who imitates the little holes on the surface of the woodwork of old furniture, so as to pass off

clever reproductions for really ancient cabinet work. The little holes to imitate those of the true insect furniture-borer are sometimes produced by discharging a gun loaded with fine shot at the piece of furniture which is to be passed off as ancient. But knowing purchasers probe the holes so made with a carpet needle, and discover the lead-shot sunk in the wood. Hence there has arisen a profession of specially-skilled "worm-eaters," who, by careful boring, imitate the holes made by insect grubs.

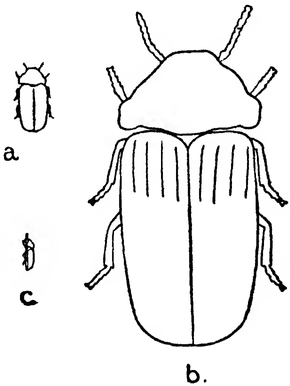


FIG. 21.—*a*, the death-watch beetle (*Xestobium tessellatum*) of the natural size (one-third of an inch long); *b*, the same beetle enlarged; *c*, the beetle (*Anobium domesticum*) whose grub is the furniture-worm, of the natural size, a side view.

And now we come at last to the actual, real furniture-worm or grub. It is the grub of a small beetle—the *Anobium domesticum*, scarcely one-fifth of an inch long (Fig. 21*c*), greyish-brown in colour, of a cylindrical shape, with the head completely concealed or overhung by the next division of the body, the thorax. The grubs are longer, soft, pale, and fleshy. The sign of the presence of the *Anobium* in your furniture is the existence of small circular holes here and there on the surface of the wood, with occasionally a little heap of yellow dust on the ground beneath them. This last sign is in fact the only proof you can have that the holes are not ancient and the burrows deserted, and that the enemy is still alive and at work. Rarely, if ever, can you see either the grub or the completed beetle into which it changes after forming a

cocoon within the burrows, for they very seldom leave their excavations. But if you break up the wood you will find a surprising number of long, cylindrical passages, running side by side, and for many inches, through the deeper part of the wood, so that it may be quite rotten and ready to crumble, although presenting an uninjured surface save for the little round holes here and there. In these passages you will find both the grubs and the adult beetles.

A closely-allied and somewhat smaller species of *Anobium* common in houses is of a more voracious character, not confining itself to dry wood, but eating bread, biscuits, rhubarb, ginger, and even cayenne pepper. This second kind, called *Anobium paniceum*, is the real "book-worm"; it gets into old libraries, and the grubs bore their cylindrical tunnels from cover to cover of the undisturbed volumes. In a public library twenty-seven folio volumes standing side by side were perforated in a straight line by one individual *Anobium* grub or book-worm, and so regular was the tunnel thus eaten out that a string could be passed through the whole length of it, and the entire set of twenty-seven volumes lifted up at once by it.

There are one or two other grubs which less commonly injure books, and pass as "book-worms." But the most notable of the insect enemies of books and papers is a curious little wingless insect which never passes through a grub stage of existence, but hatches out in the complete form of his parents. He is about a third of an inch long, has the shape of an elongated kite, with a long tail and six legs, and is called by old writers "the silver-fish," and by entomologists *Lepisma* (Fig. 22). This little pest does not burrow, but nibbles, and has destroyed many a valuable old document and ancient book. Paste and sugar are a great attraction to him, and he will destroy a boxful of printed labels or a valuable manuscript, leaving only the ink-marked parts untouched, but ready to crumble.

Closely allied to the book-worm beetle, *Anobium*, is a larger beetle, called *Xestobium tessellatum* (Fig. 21*a*) which infests old woodwork, its grubs making correspondingly

larger tunnels. The entire woodwork of a house has had to be removed and replaced in consequence of this creature's depredation, and such pieces of furniture as a four-post bedstead have been riddled and made rotten in two or three years by its burrowing. It is still common in England in old wood-panelled rooms and in wooden mantelpieces. The most interesting fact about it is that it is the maker of those nocturnal tappings which are known as the "death-watch." It is the beetle itself (Fig. 21*a*), not the

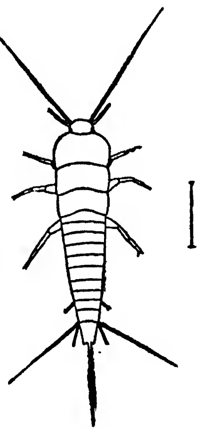


FIG. 22.—The silver-fish insect (*Lepisma saccharina*). The line to the right shows its natural size.

grub, which makes these sounds. It makes them by deliberately striking the wood on which it stands, with its head. The taps are usually from five to seven in quick succession, the sound dying away in intensity in the later strokes. A second, and even a third, beetle will then reply with similar taps from the woodwork of some other part of the room. Years ago I used to be gently lulled to sleep by these "raps" in my rooms at Oxford, accompanied by the sound of spasmodic rushes of mice behind the woodwork. At first I thought the tapping was caused by the falling of drops of water through a leaky roof, but soon ascertained the actual cause. One does not notice these tappings until the dead of night when all else is still, and

they are so mysterious and persistent that one can understand superstition arising in connection with them, and that the nerves of anyone already overwrought might be so affected by them as to lead to the belief that evil spirits are "rapping," or that a ghostly coffin is being nailed together for a dying man. The little beetle has often been tracked by a naturalist, and discovered in some concealed position nodding its diminutive but hard head with sharp jerks, and producing an almost incredible volume of sound in proportion to its size. If the beetle, when discovered, is kept in captivity in a wooden box, it is easy to set it "tapping" or "rapping" by tapping oneself with a pencil on the table on which the box is placed, when the faithful little death-watch will unfailingly reply. Possibly some of the "raps" recorded by the pioneers of spirit-rapping, when not produced by the toes of designing mediums like the young ladies of Rochester, N.Y., were actually made by death-watch beetles. It is certain that the somewhat eccentric supposition that disembodied spirits endeavour to make signals to living humanity by "rapping" owes its origin (long before the nineteenth-century craze for "spirit-rapping") to the measured tap-tap-tapping of the death-watch beetle, and the consequent superstition at a time when the beetle was not known to be the "tapper."

Whilst the bigger beetle, *Xestobium*, is the common death-watch, it has been proved that the little furniture beetle, *Anobium*, is also a tapper, making regular and persistent strokes like the ticking of a watch. Another insect, called the book-louse (*Atropos divinatoria*), very minute, only one-twentieth of an inch, soft, white, and wingless, not a beetle at all, but also a devourer of literature (Fig. 23), is declared by some good observers to be a "ticker" or "tapper," but other naturalists deny that it can make such sounds. It seems unlikely on account of the extremely small size and softness of the book-louse, but the matter needs further investigation.

A curious fact is that the grubs of beetles such as *Anobium* and *Xestobium* (or other closely allied kinds) are

not arrested in their tunnelling by soft metal. They cannot tackle iron plate or brass sheeting, but they will penetrate tinfoil and, what is more astonishing, lead plate and leaden waterpipes. Specimens showing such perforations are in the museums of Oxford and London, and I have received an account of a lead pipe packed in wood in the wall of a house being perforated by these beetle-grubs. Once at work on the wood, "the straightforward intentions" of the grub are not to be diverted by such an obstacle as lead: it goes straight on through the lead as it would through the cover of a book or a knot in the wood.

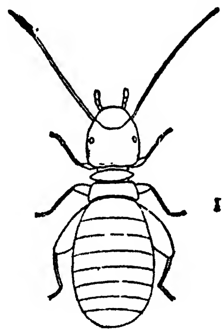


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FIG. 23.—The book-louse, or *Atropos divinatoria*, a soft, cream-coloured, wingless insect smaller than a flea. It is believed by some observers to be capable of making sounds like the ticking of a watch.

I have sometimes been asked to give advice as to the best method of destroying the furniture worm or grub. If the piece of furniture (or its pieces) can without injury be "baked" in a hot chamber for twenty-four hours, at a temperature a little above that of boiling water, that is the easiest method of destroying the pest. Or, again, I should suggest placing the piece of furniture in a refrigerating chamber for a week or two. If neither of these methods can be used the piece of furniture should be placed in a very hot room, and creosote or bisulphide of carbon or solution of cyanide of potassium should be injected with a very fine-nosed syringe into the little circular holes of the burrows on the surface of the wood; then the piece of furniture must be at once exposed to the cold, which will cause

the air to be drawn into the burrows and diffuse the volatile poison within. The "worm holes" on the surface should, as soon as the piece of furniture is quite cold, be closed by melted paraffin. If the piece of wood which it is desired to "cure" will stand submersion in water for a few minutes, and is not larger than a cricket bat, it is, of course, easy, by first warming it through and then plunging it into water containing corrosive sublimate or other poison, fairly to impregnate the burrows, and make an end of the beetles and their grubs. Painting is the common and approved means of protecting wood against these attacks, and in some positions metal sheathing is used. The method most largely used for protecting wood in the open air against "worm" and "mould" is that of forcing creosote into its pores—an improvement on the old system of painting with coal tar. A more expensive but beautiful method of protecting wood is to force hard paraffin in a melted condition by pressure into the pores. The wood becomes wonderfully firm and waterproof. Neither damp and mould, nor boring insect, nor shrimp can then penetrate it. This method was introduced some years ago, but I do not know whether it has been largely used.

AMBER

AMBER is not infrequently picked up among the pebbles of the East Coast. I once picked up a piece on the beach at Felixstowe as big as a turkey's egg, thinking it was an ordinary flint-pebble and intending to throw it into the sea, when my attention was arrested by its extraordinary lightness, and I found that I had got hold of an unusually large lump of amber. There is a locality where amber occurs in considerable quantity. It is a long way off—namely, the promontory called Samland near Königsberg on the Prussian shore of the Baltic. There it occurs with fossil wood and leaves in strata of early Tertiary age, deposited a little later than our "London clay." It used to be merely picked up on the shore there until recent times, when "mining" for it was started. From this region (the Baltic coast of Prussia) amber was carried by the earliest traders in prehistoric times to various parts of Europe. Their journeyings can be traced by the discovery of amber beads in connection with interments and dwelling-places along what are called "amber routes" radiating from the amber coast of Prussia. To reach the East Coast of England the bits of amber would have to be carried by submarine currents. Amber travels faster and farther than ordinary stones, on account of its lightness. What has been held to be amber is found, also embedded in ancient Tertiary strata, in small quantity in France, in Sicily, in Burma, and in green-sand (below the chalk) in the United States. The Sicilian amber (called "Simetite") was not known to the ancients: it is remarkable for being "fluorescent," as is also some recently discovered in Southern Mexico. But it is possible that chemically these substances are not quite the same as true amber. Amber is a fossil resin or gum, similar to that exuded by many living trees, such as gum-copal.

It has been used as an ornament from prehistoric times onwards, and was greatly valued by the Egyptians, Greeks, and Romans, and by our Anglo-Saxon ancestors, not only for decorative purposes, but as a "charm," it being supposed to possess certain magical properties.

Amber (it is generally believed) comes slowly drifting along the sea bottom to the Suffolk shore from the Baltic. Lumps as big as one's fist are sometimes picked up here. The largest pieces on record found on the Baltic shore, or dug out of the mines there, are from 12 to 18 lb. in weight, and valued at £1,000. A party sent by the Emperor Nero brought back 13,000 lb. of amber from the Baltic shores to Rome. The bottom currents of seas and oceans, such as those which possibly bring amber to our shores, are strangely disposed. The Seigneur of Sark some fifty years ago was shipwrecked in his yacht near the island of Guernsey; he lost, among other things, a well-fastened, strongly-made chest, containing silver plate. It was found a year later in deep water off the coast of Norway and restored to him! In the really deep sea, over 1,000 fathoms down, there are well-marked broad currents which may be described as rivers of very cold water (only four degrees or so above freezing-point). They flow along the deep sea bottom and are sharply marked off from the warmer waters above and to the side. Their inhabitants are different from those of the warmer water. They are due to the melting of the polar ice, the cold water so formed sinking at once owing to its greater density below the warmer water of the surface currents. These deep currents originate in both the Arctic and Antarctic regions, and the determination of their force and direction, as well as of those of other ocean currents, both deep and superficial, such as the warm "Gulf Stream," which starts from the Gulf of Mexico, and the great equatorial currents, is a matter of constant study and observation, in which surveying ships and skilled observers have been employed.

Amber has not only been valued for its beauty of colour —yellow, flame-colour, and even deep red and sometimes

blue—for its transparency, its lightness, and the ease with which it can be carved, but also on account of certain magical properties attributed to it. Pliny, the great Roman naturalist of the first century A.D., states that a necklace of amber beads protects the wearer against secret poisoning, sorcery, and the evil eye. It is first mentioned by Homer, and beads of it were worn by prehistoric man. Six hundred years B.C., a Greek observer (Thales) relates that amber when rubbed has the power of attracting light bodies. That observation is the starting-point of our knowledge of electricity, a name derived from the Greek word for amber, "electron." In Latin, amber is called "succinum." By heating in oil or a sand-bath, amber can be melted, and the softened pieces squeezed together to form larger masses. It can also be artificially stained, and cloudy specimens are rendered transparent by heating in an oil-bath.

Amber is the resinous exudation of trees like the "Copal gum" of East Africa and the "Kauri resin" or "Dammar" of New Zealand. Both of these products are very much like amber in appearance, and can be readily mistaken for it. The trees which produced the amber of the Baltic were conifers or pine trees, and flourished in early Tertiary times (many millions of years ago). Their leaves, as well as insects of many kinds, which have been studied and named by entomologists, are found preserved in it. There is a very fine collection of these insects in the Natural History Museum in London. It is probable that more than one kind of tree produced the amber-gum, and that its long "fossilization" has resulted in some changes in its density and its chemical composition. The East African copal is formed by a tree which belongs to the same family as our beans, peas, and laburnum. It is obtained when freshly exuded, but the best kind is dug by the negroes out of the ground, where copal trees formerly grew and have left their remains, so that copal, like amber, is to a large extent fossilized. The same is true of the New Zealand dammar or kauri gum, which is the product

of a conifer called " Agathis australis," and is very hard and amber-like in appearance. Chemically amber, copal, and dammar are similar to one another but not identical. Amber, like the other two, has been used for making " varnish," and the early Flemish painters in oils, as well as the makers of Cremona violins, made use of amber varnish.

A medicament called " eau de luce " was formerly used, made by dissolving one of the products of the dry distillation of amber (called " oil of amber) " in alcohol. Now, however, amber is used only for two purposes—besides decoration—namely, for the mouthpieces of pipes and cigar tubes and for burning (for amber, like other resins, burns with a black smoke and agreeable odour) as a kind of incense (especially at the tomb of Mahomet at Mecca). These uses are chiefly Oriental, and most European amber now goes to the East. In China they use a fine sort of amber, obtained from the north of Burma. The use of amber as a mouthpiece is connected with its supposed virtues in protecting the mouth against poison and infection. It is softer than the teeth, and therefore pleasant to grip with their aid ; but as a cigar or cigarette tube it is disadvantageous, as it does not absorb the oil which is formed by the cooling of the tobacco smoke passing along it, but allows it to condense as an offensive juice.

Forty years ago an old lady used to sit in the doorway of her timber-built cottage in the village of Trimley (where there are the churches of two parishes in one churchyard), smoking a short clay pipe and carving bits of amber found on the Suffolk beach into the shape of hearts, crosses, and beads. She would carve and polish the amber you had found yourself whilst you joined her in a friendly pipe. You were sure in those days of the genuine character of the amber, jet, and agate sold as " found on the beach." Nowadays these things, as well as polished agates and " pebbles from the beach," are, I am sorry to say, manufactured in Germany, and sent to many British seaside resorts, like the false coral and celluloid tortoiseshell which,

side by side with the genuine articles, are offered by picturesque Levantines to the visitors at hotels on the Riviera, and even in Naples itself. Nevertheless, genuine and really fine specimens of amber picked up on the beach and polished so as to show to full advantage their beautiful colour and "clouding" can still be purchased in the jeweller's shop at Aldeburgh on the Suffolk coast near the great pebble beach of Orford Ness.

There are difficulties about using the word "amber" with scientific precision. The fossil resins which pass under this name in commerce, and are obtained in various localities, including the Prussian mines on the Baltic, are undoubtedly the product of several different kinds of trees, and, from the strictly scientific chemical point of view, they are mixtures in varying proportions of different chemical substances. The merchant is content with a certain hardness (which he tests with a penknife), transparency, and colour, and also attaches great importance to the test of burning a few fragments in a spoon, when, if the material is to pass as "amber," it should give an agreeable perfume. Scientifically speaking, "amber" differs from other "resins," including copal, in having a higher melting point, greater hardness, slighter solubility in alcohol and in ether, and in containing "succinic acid" as an important constituent, which the other resins, even those most like it, do not. True amber thus defined is called "succinite," but several other resins accompany it even as found in its classical locality—the Baltic shore of Prussia—and, owing to their viscid condition before fossilization, may have become mixed with it. One of these is called "gedanite," and is used for ornamental purposes. It is more brittle than amber, and contains no succinic acid. It is usually clear and transparent, and of a pale wine-yellow colour.

It is not possible to be certain about the exact nature of what appears to be a "piece of amber" thrown up on the seashore, without chemical examination. A year or two ago a friend brought to me a dark brownish-yellow-coloured piece of what looked like amber, which (so my

friend stated) had been picked up on the shore at Aldeburgh. It was as big as three fingers of one's hand, very transparent and fibrous-looking, owing to the presence of fine bubbles in its substance arranged in lines. I found an exactly similar piece from the same locality in the collection of the Natural History Museum. It was labelled "copal," and, I suppose, had been chemically ascertained to be that resin and not "amber," or, to use the correct name, "succinite." How either of these pieces got into the North Sea it is difficult to say. Though the "copal" of commerce is obtained from the West Coast of Africa, it may occur (though I have not heard that it does) associated with true amber in Prussia. A fossilized resin very similar to copal is found in the London clay at Highgate and elsewhere near London, and is called "copalite." It is possible, though not probable, that the bits of amber found on our East Coast beaches are derived from Tertiary beds, now broken up and submerged in the North Sea, and do not travel to us all the way from the Baltic.

SAND-HOPPERS

WHEREVER there is a sandy seashore with here and there masses of dead seaweed and corallines thrown up by the waves, you will find sand-hoppers feeding on the debris. They are crustaceans, like crabs, shrimps, and barnacles, but in general aspect resemble enormous fleas. I hope that this comparison will not enable any reader at once to picture the less familiar by the more familiar. A good-sized sand-hopper is about half an inch long, and jumps not by means of a specially large pair of legs as the flea does, but by the stroke of the hind body, the jointed rings of which are carried curled downwards and ready to give a sudden blow. The sand-hopper (Fig. 24, a) has some of the rings or segments of the mid-body distinct, and not fused with those of the head or overhung by a great shield as in the lobster, crab, and shrimp. His walking legs and jaw-legs are also not quite of the same shape, though similar to those of a lobster, and his two little black eyes are not mounted on stalks, but are flush with the surface of the head. There are two quite distinct kinds of sand-hopper which live in crowds together on our sandy shores. They are not very different, but still are distinguished by naturalists from one another; one is called Talitrus (Fig. 24, a), the other Orchestia (Fig. 24, b). They are very similar in appearance and structure to a freshwater creature common in weedy streams, which has no English name (except the general one of "freshwater shrimp"), and is called by naturalists Gammarus.

In the open sea there are many hundreds of kinds of small crustaceans resembling the sand-hoppers in their compressed (not flattened) shape of body and in the details of their legs and the grouping of the joints of the body. Many of the smallest crustaceans which swarm in the surface waters of the sea and form part of that floating

population, mostly of small transparent or iridescent and blue creatures, which we call the " plankton," or " surface-floating " population, and may be gathered by towing a very fine net behind a boat on a quiet day, can produce flashes of light which are vivid enough when seen at night. They contribute, together with jelly-fish and the teeming millions of minute bladder-like Noctiluca, and other unicellular animalcules, to produce that wonderful display

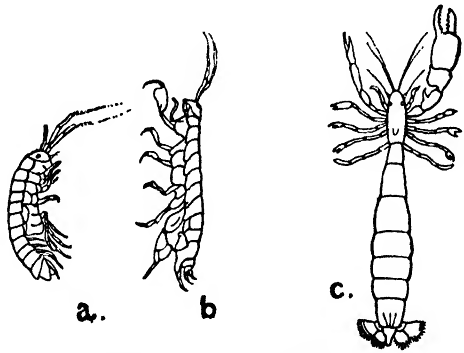

FIG. 24.—a, Talitrus locusta, b, Orchestia littorea, the two common kinds of " sand-hopper." Of the natural size. c, A kind of small lobster which burrows in the sand, Callianassa subterranea. About two-thirds the natural size, linear.

seen from time to time on our coasts, and called " the phosphorescence of the sea." These minute crustaceans produce flashes of light by suddenly squeezing from pits or glands in the skin a secretion which is chemically acted on (probably oxidized) by the sea water, the chemical action setting up light-vibrations, but not the usual excess of heat-vibrations to which we are accustomed when light accompanies ordinary " burning " or " combustion."

Other crustaceans of several kinds, of an inch and more in length—transparent, delicate creatures, resembling small prawns in appearance—also produce light. Some of them are known by names referring to this fact, such as Lucifer (light-bearer) and Nyctiphanes (night-shiner). They

possess special lantern-like knobs scattered about on the body, which have transparent lenses, and resemble small bull's-eye lanterns. Some have a median row of four lanterns at the hinder part of the body and three paired lanterns farther forward (Fig. 25), but one kind has as many as 150 dotted about. These lanterns were only a few years ago thought to be eyes, and their elaborate microscopic structure was described as that of an eye. Of course, this was due to the fact that dead preserved specimens were studied, and not the living animal. Some

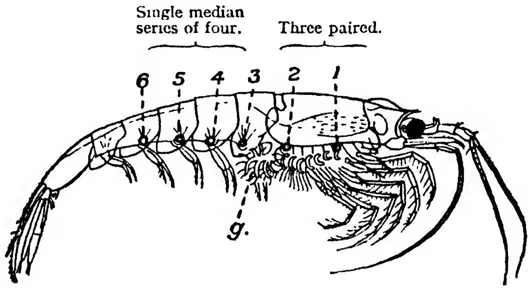

FIG. 25.—A Phosphorescent Shrimp (Euphausia pellucida). The median lamp-like phosphorescent organs are numbered 3 to 6. The right side lanterns of two thoracic pairs are numbered 1 and 2, whilst there is another pair on the outer edge of the stalked eye, making ten lanterns in all. *g*, points to the hindermost gill. Magnified five diameters.

twenty years ago I witnessed a most impressive exhibition of these phosphorescent shrimps at the house of my friend Sir John Murray, of the *Challenger*, at Millport, on the Clyde. He had obtained them (the kind called Nyctiphanes) in great quantities at a depth of ninety fathoms in the great Scotch fiord, and amongst other curious facts about them had shown that they enter Loch Fyne in vast numbers, and are the special nourishment of the celebrated Loch Fyne herrings. It had been noticed that the intestine of the plump, well-fed herrings is full of a deep-black substance, and Sir John Murray showed that this was the black, indigestible pigment of the eyes of the hundreds of phosphorescent shrimps swallowed by these favoured fish,

which owe their fine quality to their special opportunity for feeding in the depths of the loch on the exceptionally abundant and nutritious light-producing crustaceans! At night my friend showed me a large glass vessel holding four or five gallons, in which were a hundred or so of the phosphorescent shrimps swimming around. We turned out the lamps of the room, and all was dark. Then a gentle tap was given to the jar, and each little crustacean lit up, as though by order, its row of minute lamps on each side of its body, swimming along meanwhile, and reminding one of a passenger steamer, as seen from the shore, as it glides along at night with its lights showing through a row of cabin windows. The shrimps' lights shone steadily for a minute or so, then ceased, and had to be lit up again by again signalling their owners by knocking on the glass. These little lamps, with their bull's-eye lenses, are far more elaborate structures than the glands which in other cases cause a flash by discharging a luminous secretion into the water. They are even more elaborate than the internal permanent phosphorescent structure of the glow-worm (an insect, not a crustacean), which has no condensing lens.

I have mentioned these phosphorescent organs of small and smallest crustaceans because not many years ago a French naturalist, my friend Professor Giard, found that many of the sand-hoppers on the great sandy shore near Boulogne are phosphorescent. A year or two later I found them myself on the shore above tidemark at Ouistreham (Westerham), near Caen, where they had actually been mistaken for glow-worms! It was easy at night to pick up a dozen phosphorescent sand-hoppers during a stroll of five or ten minutes on the sands. Yet I have never seen them nor heard of their being seen on the English coast, and one of the results which I hope for in mentioning them here is that some of my readers will discover them on British sands and let me know. The remarkable fact about the luminous sand-hoppers is that they have no apparatus for producing light, and, as a matter of fact, do not produce it! Their luminosity is a disease, and is due

(as was shown by that much-beloved teacher and discoverer the late Professor Giard) to the infection of their blood by a bacillus. Hence it is only here and there that you see the brilliant greenish ball of light on the sand due to a phosphorescent sand-hopper. And when you pick it up you find that the poor little thing is quite feeble and unable to hop. Examine its blood under the microscope and you find it teeming with excessively minute parasitic rods like those which cause the phosphorescence of dead fish, of stale bones, and occasionally of butcher's meat. Similar bacilli may be obtained by cultivation from any sea water, and in such abundance that a room can be lit up by a bottleful of the cultivation. Perhaps all the light-producing bacteria or bacilli are only varieties of one species—perhaps they are distinct species. Whether a species or a variety, that which gets into the blood of the sand-hopper and gives it the luminosity of a glow-worm, inevitably and rapidly causes its death—a severe price to pay for brief nocturnal effulgence. Some of the germs can be removed on a needle's point from the dead sand-hopper and introduced by the most delicate puncture into a healthy sand-hopper or into a young crab, with the result that they too become illuminated, the bacillus multiplying within them. Being thus morbidly illuminated and having astonished the crustacean, not to say the human world, by their alarming brilliance, they quickly perish: a little history which may be read as a parable. The sand-hoppers give the disease to one another. It is, of course, a merely non-significant thing that the bacillus happens to set up light vibrations. Its chemical activity is concerned with its nourishment and growth, and in the course of these processes it not only produces light but poisonous by-products which kill its host. Some day we may get an "immune" race of sand-hoppers who will acquire the illuminating bacillus and defy its poison. Then we shall have a permanent and happy breed of brilliant sand-hoppers illuminating the dark places of the seashore.

It is conceivable that some of the disease-producing

bacilli (bacteria, cocci, etc.) which multiply in man's blood and tissues should also produce light vibrations, and if one could be found that would render the blood luminous, whilst not producing much pain or *malaise*, no doubt some excuse would be found for its use as a fashionable toilet novelty. Cases are on record of luminosity of the surface of the body and its secretions being developed during serious illness by human beings, especially in acute phthisis; but these ancient records need confirmation.

Luminous bacilli or bacteria only give out light when free oxygen is in the water or liquid inhabited by them. A chemical combination of the oxygen with substances in the bacteria is the necessary condition of their evolution of light. When frozen, these bacteria cease to be luminous—the chemical combination cannot take place when the substance of the bacterium is frozen solid and maintained in that condition; the liquid condition is a necessary condition for these changes. These luminous bacteria have been used recently by Sir James Dewar in the Faraday Laboratory of the Royal Institution (where Sir James has shown them to me), for the purpose of investigating the action of intense cold on living matter. Although their luminous response to oxygen is arrested when they are frozen, yet immediately on allowing the temperature to rise above freezing-point the response of the living matter to oxidation recommences, and a luminous glow is seen. Hence we have in this glow a ready means of answering the question, "Does extreme cold, of long duration, destroy the simplest living matter?" Sir James Dewar has exposed a film of these bacteria to the extremest degree of cold as yet obtained in the laboratory, that at which hydrogen gas is solidified, and he has kept them in this, or nearly this, degree of cold for several months. Yet immediately on "thawing" the luminous glow was visible in the dark, showing that the bacteria were still alive. Curiously enough, whilst all chemical action in living matter can be thus arrested by extreme cold, and yet resumed on rise of temperature and restoration to the

liquid condition, so that the old phrase and the conception of "suspended animation" are justified—yet there is one widely-distributed form of activity, the effect of which the bacteria, even when hard frozen, cannot resist, namely, that of the blue and ultra-blue rays of light. These rays, if allowed to fall on the hardest frozen bacillus, get at its chemical structure, shake it to pieces, destroy it. Hence Sir James Dewar argues that, whilst it would appear that the extreme cold of space would not kill a minute living germ, and prevent it passing from planet to planet, or from remotest space to our earth, yet one thing which is more abundant in space than within the shell of our atmosphere is absolutely destructive to such minute particles of living matter, even when hard-frozen, and that is intense light, the ultra-visible vibrations of smallest wave-length.

FIG. 26.—A dance on the seashore a sketch by Edward Forbes (1841).

GLACIERS

PEOPLE who have not seen a glacier, walked on a glacier, chipped into it with an ice-axe, and followed it up from its melting " snout " and decidedly dirty, rock-strewn lower end to the regions where it is pure and white, split into yawning chasms and raised into great teeth or pinnacles—those, indeed, who have not followed it yet farther from these middle heights, far on up the rocky sides of a great mountain, until the region is reached where it ceases to be ice, and becomes a mass of soft, powdery snow—do not know one of the most curious, unimaginable, and powerful agencies in Nature. We inhabitants of the British Isles, were we confined to our limited territory, and un-informed by travellers as to the wonders of the snow-world, would never guess or infer from anything we ever see here that such things as glaciers exist. There is no parallel to the peculiarity, the unexpected and astonishing quality, of a glacier. Even a volcano is not so remote from what one could have expected. Rivers, lakes, and seas we know, and we can imagine them bigger and deeper. Waterfalls and great white clouds, in fact all the forms of water, are familiar to us. Mountains, even winter snow-capped mountains, we sometimes see in our own island, and can imagine them bigger. We have handled ice and snow, too. Yet nothing which we know by experience here prepares us for the complete change in the appearance, character, and behaviour of snow when it is piled in vast thickness on the slopes of mountains so high that it is ever renewed, and never melts away on their peaks and shoulders.

We are accustomed to see snow slowly melt and run away as water, and the more observant will have noted that in prolonged frost, snow, even when piled in heaps by the roadside, disappears without thawing. It evaporates,

slowly but surely, straight away into the form of gas—invisible aqueous vapour. That is a rather unusual property for a solid body to possess. In that way a certain return of evaporated snow to the atmosphere from which it was precipitated in crystalline flakes takes place. But the amount is small. We are not accustomed to find a solid body evaporating. Volatile liquids are common, but volatile solids are unusual. The metals and rocks do not behave in this way. The only familiar parallels to ice and snow in this respect are the vegetable product camphor and some allied bodies. They pass directly from the solid to the gaseous state, and the invisible gaseous camphor can be precipitated as "a snow" of crystalline camphor on a glass shade placed over a lump of that substance.

There are some bodies—the metal bismuth is one of them, sulphur and hard paraffin also are of the number, and water is another—which in passing from the liquid to the solid state expand—actually increase in volume. It is far more usual, and seems to us a more "natural" thing, for a liquid to contract when, owing to cooling it, becomes solid. The exceptional property possessed by water of expanding when frozen is of enormous effect in the wear and tear of the earth's surface. It is thus that the strongest water-pipes, which the combined wickedness and ignorance of plumbers and architects lead them to place on the outside of our houses, instead of inside near the chimneys, are burst by frost. And similarly it is owing to this swelling of water when freezing that the wet soil and surface rocks are, when frozen in winter, broken and rendered permeable to later rains. But even more striking is the result of this bursting action of freezing water upon the great rocky sides of mountains. The water, formed by melting snow and by rain, lodges in cracks and fissures of the rocks, and, when the cold of winter comes on, it freezes and consequently swells in volume, and so shatters the imprisoning stone. Thus it breaks off huge masses and helps to wear away the mountain peaks and sides. It is owing to the expansion of water on becoming solid that a given bulk of

ice is lighter than the same bulk of water, and that therefore ice floats on water, and our streams and lakes do not freeze from bottom to top.

Important and exceptional as are these properties of water—producing great results, which we can observe in the frozen world of the Alps—they do not help us to the understanding of a glacier, nor would they suggest to us as a natural process the production of glaciers by the change of great heaped-up masses of snow on mountain sides. The one familiar property of snow, or powdered ice, which has to do with the conversion of mountain snow into the huge rivers of solid ice called "glaciers," is the curious "binding" quality which enables us to make "snowballs" by squeezing handfuls of snow. Every schoolboy knows that if one takes up a double handful of snow during a hard frost and lightly presses it, it remains a loose powder. But if one squeezes the snow very firmly and persistently (or with less squeezing if a slight thaw has set in), the particles adhere to one another, and the snow becomes hard and more or less compact ice. Boys consider it an unfair and brutal thing to squeeze a snowball so much as to make it thoroughly solid, since it then becomes as dangerous a missile as a big stone. A certain moderation in the manufacture is held to be correct, giving the snowball a firm crust, but one which can easily break on the face of the opponent at whom it is thrown, thus allowing the still powdery interior lightly to overwhelm him.

This property of snow—viz. that its particles become, as it were, fused together so as to form a continuous mass of ice when it is squeezed (that is, subjected to pressure) has been carefully examined. The snow particles seem at first sight to behave as though they were viscid or "sticky"—in fact, as powdered wax or resin would behave. Yet they are not really viscid at all, but consist of loose crystals of ice, small but hard, and with no tendency to "flow" or soften. Their binding property is found to be due to the fact that pressure lowers the degree of heat, as registered by a thermometer, at which ice melts. The same lowering

of the melting-point by pressure has been observed in other bodies which expand when solidifying—for instance, sulphur and paraffin. In ordinary circumstances ice melts and becomes water at the temperature registered as 32 deg. on the Fahrenheit scale or zero on the Centigrade scale. A pressure equal to a weight of 2,000 lb. on the square inch of surface lowers the melting-point of ice by 1 deg. Centigrade. A very much smaller pressure has its due proportional effect, and lowers the melting-point a little. So that merely squeezing powdered ice in the hand or in a squeeze-mould causes it to melt a little—and even at the great degree of cold (sometimes experienced in the winter on the Continent, but rarely in England) of 18 deg. below zero Centigrade, which is very nearly equal to zero Fahrenheit, a French experimenter has, by applying to ice a pressure (a weight) of several thousand pounds to the square inch, converted it into water. It is, of course, obvious that when ice is caused to melt ever so little by pressure, the removal of the pressure will lead to the re-freezing of the water produced. Hence we see that by "kneading" the powder of ice-crystals which we called "snow" a minute quantity of water is first produced by the squeezing, and then immediately is re-frozen when the pressure is relaxed by the "kneading" hand. Consequently at every squeeze a little air is driven out from the powder, a little water takes its place, and when the squeeze is relaxed this becomes solid, and cements neighbouring crystals together, until, by repeated squeezing and relaxing, the whole lot of crystals may be joined together into a solid mass by the re-freezing of the water formed by the slight amount of melting. The ice so formed encloses a great many tiny, almost invisible bubbles of air. The process of melting by pressure and re-freezing when the pressure is removed is called "regelation." A glacier is nothing but a huge snowball formed by regelation. The warmth of the sun causes the surface layer of snow to melt a little; the water so formed percolates into the deeper layers where the heat of the sun does not penetrate.

It freezes again, and the solid mass lying on a steep slope begins to press and move downwards. It breaks and falls, and "regelates" with neighbouring similar masses owing to their mutual pressure. Always the slowly, or maybe quickly, sliding masses adhere by regelation and add to their solid bulk by this kind of adhesion just as the much smaller rolling snowball made by boys in the winter binds to it the snow over which it is turned, and increases its solidity and bulk at a rate which has become proverbial.

Snow which falls when the air is at a temperature below freezing has the form of six-rayed stars or crystals, of great beauty and variety. In the highest Alpine regions the fallen snow gradually loses its crystalline form, and becomes granular or powdery. It is known as the "nevé," or "firn." Occasionally it is coloured red by a microscopic plant called *Sphærella nivalis*, and when it melts a certain kind of wheel animalcule often inhabits the small pools so formed both in the Alps and on the Arctic and Antarctic snows. Generally the nevé remains firm and hard; the foot sinks but little into it. The water which results from its melting sinks through it and freezes with the snow below into a solid layer. Each year's deposit forms a layer from 1 ft. to 3 ft. in thickness, and is covered up to a great depth by the next year's snow, which again during the warmer weather contributes its frozen layer. Thus below the surface the nevé has a banded or stratified structure, and when it has passed in the course of years far from the place of its original formation down the rocky bed of the creeping glacier, you may still observe this laminated or stratified structure of annual layers. The nevé is often of very great depth or thickness. At the top or "source" of many Alpine glaciers it is as much as 1,000 ft. thick. Avalanches are falls of the imperfectly consolidated snow on slopes too steep to permit more than a small thickness of the powdery material to lie at rest. An immense quantity of snow is thus regularly brought

down by avalanches to the lower regions, and is melted every spring, when there is a loosening of frozen bonds by the daily sunshine. The deeper layers of the nevé are under vast pressure from the overlying layers, and become crushed and regelated into solid ice. They slowly slide as a continuous layer of great thickness down the slopes on which they have accumulated, and as they advance the powdery snow on the surface both evaporates and melts until the deeper-lying ice is bare and shows on the actual surface. The nevé now ceases to exist as such ; it has become a glacier, a slowly-moving river of solid ice. It is this incredible moving thing which no one would ever have foreseen as the product of a heap of snow, no matter how vast or where accumulated. As it moves downwards the mass is subjected to immense pressure, both from its own weight resting on the rocks, and from lateral pressure or squeezing from the sides of the bed or hollow, which hold it as a river of water is held by its banks. The continuous and varied pressure and pull, tear, and squeeze of the huge mass, in its irregular bed, alter a great deal the character of the ice as it advances.

Glaciers differ in length according to the amount of snow which is annually furnished by the high collecting ground of the nevé, and also according to the steepness of the bed along which they travel, as well as to some extent in relation to the greater or less heat of the valleys into which they descend. The fact that the ice which is melting away at the snout, or lower end, of a glacier has gradually descended from above, has been long known by the mountain folk, but it was only in the last century that the rate of descent was measured. It varies from 150 ft. to 1,000 ft. a year ; it varies in different parts of the same glacier, and at different seasons of the year, and in different years. In the summer an average sample of a glacier will advance a foot and a half a day in the middle, and a foot or less at the sides. It has been calculated that a particle of ice would take about 500 years to descend from the summit of the most beautiful of all the great Swiss

mountains—the Jungfrau—to the end of her greatest glacier, that called the great Aletsch, which expands its melting "snout" below the Bel Alp over the Rhone valley.

The Swiss glaciers had been, on the whole, increasing in size for some 500 years until 1820, when they retreated until 1840, and again advanced until 1860. Since then they have greatly diminished, though some are now advancing again. Many are the lamentations of old lovers of the Swiss mountain valleys over the shrinking of the Mer de Glace of Chamonix, the Aar Glacier of Rosenlaui, and the Rhone Glacier. But they will extend again some day. The Yengutsa Glacier in the Himalayas has increased two miles in length since 1892. Another Himalayan glacier (that of Hassanabad) had slowly shrunk back during a long period until seven years ago it was six miles shorter than it had been fifty years before; then suddenly it advanced over the lost ground and actually grew six miles—pushed its snout forward six miles, back to its old position—in three months!

The great extension at a remote prehistoric period of the Swiss glaciers, and the general existence in past ages of glaciers and an ice-covering of the land in Central and Northern Europe, are proved by the following four pieces of evidence: First, the existence of "moraines," those huge embankment-like piles of broken rocks, many even hundreds of miles distant from the existing glaciers, often in positions which it is clear from the "lie of the land" the present glaciers would have reached if they had been enormously increased in size; second, the existence of detached rocks, called "erratic blocks," which are found perched on the surface of the ground at a vast distance from the mountains from which their mineral structure shows them to have been carried; third, the occurrence of rock surfaces far from existing glaciers, which nevertheless show the peculiar polishing and scratching which is made only by glaciers; fourth, the existence in more southern regions of the remains of plants and animals of kinds

belonging to a cold climate, and now only found in the far north, as well as the existence of Alpine plants in regions now separated from the cold upper parts of Switzerland (where they flourish) by vast expanses of warm country, over which they could not spread in the present condition of the climate.

The two great glaciers—that of the Rhone valley and that of the Rhine valley—have been carefully traced, and their length and breadth and depth ascertained. The glaciers which now seem to us so enormous and powerful, as they push their snouts into the end of the Rhone valley and the side valleys of the canton of the Valais—the great trough which runs for a hundred and twenty miles from near the Furca Pass to the Lake of Geneva—are but the surviving roots of the immense Rhone glacier which filled the whole of the valley and the Lake of Geneva itself, and flowed on as far as, and even beyond, Lyons! The Rhone glacier, the great Aletsch, the Gorner, and very many others extended along their present course, met, and formed one huge advancing stream of ice! The great glacier of the Rhine extended from the Swiss Alps northwards as far as Coblenz, on the Rhine; others at the same time spread down the southern slopes of the Alps into Lombardy. We find the moraines of the vast Rhone glacier at various parts of its course, these vast heaps of rock fragments having been piled up and left by the glacier, some when it was at its fullest extension, some as it shrank towards its present pygmy dimensions. The high, long terrace of St. Paul, which one sees more than a thousand feet above the Lake of Geneva, at Evian, is a moraine, and all over Switzerland, in the lower valleys, fifty or a hundred miles away from existing glaciers, you come upon these strange, long, straight hills, resembling enormous railway embankments, just as the moraines at the sides of the existing glaciers resemble ordinary railway embankments. We can ascertain the height to which the old huge glaciers filled the present valleys by the polishing and scratching of the rocks as well as by the remains of moraines. At

Martigny, where the Rhone valley takes a sharp turn, the glacier filled it to a height of 5,000 ft. above the present river! At Geneva it stood as a solid, continuous sheet more than 3,000 ft. over the level of the present city and lake; and it spread out as an immense covering of solid ice right away to the Jura Mountains beyond Neuchâtel and its lake, its surface there being 3,000 ft. above the present level of the lake! A vast sea of ice in fact covered the whole country, with the exception of the high mountain-tops, from Lyons to Basle and along the Rhineland to Coblenz in one direction, and across Bavaria to beyond Munich and Salzburg! Whilst this was the condition of Switzerland more northern regions were also completely involved in an ice-covering. Glaciers existed in Wales and Scotland, as proved by the moraines still left there, the erratic blocks, and the ice-polished and scratched rocks of the mountain valleys. The whole Scandinavian peninsula was overwhelmed by a vast glacier. The ice from the Norwegian glaciers extended to our Eastern shores, and immense deposits of irregular ice-borne fragments were accumulated there, and again and again torn up and re-deposited by the water and by floating ice (the "drift" and the "boulder clay" of East Anglia). The whole of the northern half of the temperate zone was thus glaciated or ice-ridden. This astounding and terrible state of things is what is referred to as "the glacial period."

The inquiry as to what were the causes of this extremely different condition of regions of the earth, now so fertile and richly inhabited, is a pressing one. We must be anxious to know how it came about and whether it is likely to come again. One result of the great amount of study given to the subject during late years is the discovery that there has not been one glacial period but at least four, separated from one another by long warm periods in which the ice retreated to something like its present limitations and then again overwhelmed the land. And the curious thing is that three of these have all occurred in the quite

ıate geological period which we call " Pleistocene," since (as an instance which will have some familiarity for English readers) the accumulation of the shelly marine deposits in the southern area of the North Sea which we call the Red Crag and Coralline Crag of Suffolk, and the Yellow and Black Crag of Antwerp. One glacial period immediately preceded the Red Crag. These deposits (called " Pliocene ") are not very old or deep in a diagram representing the thickness of the various strata of the earth's crust. They have only some 200 ft. above them, whilst below them there are (before we come to the chalk, a great landmark in the geology of this part of the world) 2,400 ft. of the sands and clays which are called Miocene and Eocene ! Passing on downwards from the uppermost " chalk " to the Silurian strata (without going any further down), there are 29,000 ft. of deposit ! So we see that the three or more glacial periods and interludes of the Pleistocene period correspond to a very brief chapter of geological history, and that the latest. In fact, we know that man chipped his flint implements and dwelt in caves in Europe before the greatest of these glacial periods. When we examine the deposits of the periods preceding the latest Pliocene, and the fossilized remains of plants and animals contained in them, it is the fact that we get no indication of other and earlier " glacial periods " in this part of the world, until we get into a very remote period before that of the chalk and the oölites. The " breccias," or deposits, of large angular rock fragments of the new red sandstone or " Triassic " period bear indications, in the form of scratches and polishing of the stones, of the action of glacier ice. But the negative evidence is not conclusive, and it may well be that glacial periods earlier than those of the latest epoch (the Pleistocene) have come and gone, but left no evidence of their occurrence in the much altered and scattered deposits which form the rocks of the earth's crust.

The most striking fact which the investigation of this subject has brought into prominence is this : The extension

of the glaciers even to the limit which was reached in the last great glacial period of prehistoric times does not imply any very extreme climate. That is to say, a small change in our present climate would bring back the extension of glaciers, and give us another glacial period. Glaciers require heat as well as cold—heat to raise the vapour from adjacent regions, which is then condensed as snow on the higher and colder territory. The presence of an excess of aqueous vapour in the atmosphere, even without the formation of cloud, has a very large and important result in stopping the access of heat from the sun to the region of the earth protected by the moist atmosphere. An increase of watery vapour in the atmosphere of the northern hemisphere would materially lower its temperature. A succession of damp summers would do more to enlarge the glaciers than a series of severe winters. It is estimated by competent authorities that a fall in the average annual temperature of only 10° F. (provided that the summers were cold and damp) would suffice in a few decades to bring about the return of glacial conditions in the temperate region of the northern hemisphere. The present snow-line, or level of perpetual snow, is, in this part of the world, at the height of 9,000 ft. above sea-level. As we ascend from the sea-level the temperature decreases by about 1° F. for every 350 ft. we mount. A fall of 10° in temperature would accordingly bring the snow-line down by 3,500 ft.—that is, to 5,500 ft. above sea-level—and the lower limit to which the glaciers reach, which is now about 4,000 ft. above sea-level, would descend to 1,200 ft., which is lower than the level of Geneva. Changes in the outline of the continents and in the direction of the great warm currents of the ocean, together with changes in the growth of forest and the extent of desert land on the continents, might, by affecting the habitual disposition of cloud and of vapour, go far to reduce the average annual temperature of north temperate regions by 10°.

It has, on the other hand, been held that the periodic and regular "wobbling" of the earth as it spins on its axis is

largely accountable for the fall of temperature in the temperate zone at regularly recurring intervals. The axis of rotation of the earth moves round in a circle, as one may see the stem of a well-spun top slowly move in a circle whilst the top "sleeps." The earth takes about 26,000 years to complete its wobble, and in that cycle there is a period when there is least and a period when there is most sunshine falling on the polar regions—owing to the difference in the inclination of the pole to the sun. It is held that this difference is enough to produce the fall of 10° F. required to give us a "glacial period" in this part of the world. At any rate, in combination with the changes conducing to formation of vapour and cloud which I have mentioned above, it would probably be effective.

Geologists are not agreed on this subject, but they have established, as I have stated above—by definite proof—the recurrence of glacial periods separated by long intervals of warmer climate during the latest period of geological time, the Pleistocene. The most convincing proof of the occurrence of three periods of great extension of European glaciers with intervals of a milder climate has been obtained by studying the ancient moraines. The great mass of heaped-up rock fragments left as a moraine by a once extended glacier which has dwindled and retreated, becomes altered on its surface in the course of a few thousand years by change and decomposition of the rock fragments. A special surface-layer is produced. Now when the glacier again, after some thousands of years, extends and deposits a new moraine over the old one, and again retreats, it is found to be possible to distinguish the later from the earlier moraine by the "special surface-layer" of the old moraine, which marks it off from the new material piled over it. Thus three extensions have been traced in Bavaria, and in other regions within the area of the great Swiss glaciers of the glacial period. These "extensions" and "retreats" are not small variations of two or three miles, such as we see occurring in Switzerland under our eyes within recent

years. They refer to differences of hundreds of miles in length, and to incalculable differences in the volume of solid ice concerned, due to periods of long-continued climatic differences separated by many thousand years. It is not possible to induce any cautious geologist to state how many thousand years separate us from the last great glacial extension, nor how many thousands of years separated it and those which occurred earlier in the Pleistocene epoch and at the end of the Pliocene from one another. If the astronomical cause were really the determining one, we might conclude that intervals of about 26,000 years were what occurred between the full severity of each glacial period. But on other grounds such intervals are considered to be too short, and doubt and speculation surround the attempt to put the period into figures of so many thousand years. For instance, if 26,000 years is all that should separate a future glacial period from the last (which seems to have been the greatest and most severe), we do not get enough time (even supposing that we are within a couple of thousand years of another glacial period) to account for all the changes in the surface of Western Europe, and in the animals and men upon it. The Neandermen, the mammoth, the hyena, the lion, the rhinoceros, bison, and other large game swarmed here then, and there was no "channel" separating England from the Continent. We know a long succession of events which have occurred since then—the arrival of the Reindeer-men, their disappearance, and the conversion of Europe into a pastoral and agricultural land by the men of the polished stone weapons, the arrival of the later bronze-using men, and later still the introduction of iron. Most "prehistorians" consider that much more than twenty thousand years has elapsed since the last great glacial period covered North and Central Europe with ice. Professor Penck, a very high authority, estimates four hundred thousand years as having passed since the first glacial extension of Pleistocene times. But it is not possible in the present state of knowledge to hold with conviction to any exact estimate,

nor to be quite sure that another glacial period is not already due !

The ice which forms by freezing on a lake or pond differs a good deal in appearance and structure from glacier ice. If a piece of lake or pond ice is melted in warm air, the surface gradually liquefies, and the whole remains clear. But if a piece of dense glacier ice from the deeper part of a glacier (such as you may get from one of the " ice-caves," often cut for show at the snout of a glacier) is similarly melted, very fine cracks appear in it, and gradually the lump breaks up into irregular crystalline pieces. They are called " glacier grains," and are usually about the size of a walnut, but may be smaller or bigger. They are separate groups of ice crystals, and the glacier ice is made up of these innumerable units tightly wedged and fused together. Their origin is not properly understood, but it appears that the water which percolates the freshly formed nevé, and freezes so as to solidify the mass, has more mineral matter in solution than have the snow crystals themselves, and melts more easily (at a lower temperature). Hence the sun's rays liquefy this cementing ice, and leave the purer crystals as knob-like glacier grains. I have already mentioned the stratified structure to be seen in the newer ice of a glacier, but there are also the dirt bands which form by the collection of rock debris in transverse fissures of the glacier, and are carried on and spread out as curved bands crossing the glacier from side to side when it has flowed some miles on its course and expanded in a broadened bed.

A great deal of attention has been given to the question, " Why do glaciers descend ? " Though ice is not a viscous body, it yet has some of the properties of one when it presents itself in huge masses, such as are glaciers. It can bend and spread and alter its shape in response to pressure ; it splits and reunites its broken surfaces owing to the property of " regelation " which I described above. In a warm atmosphere a cube of pitch, or of sealing-wax, or

wax, as big as a quartern loaf, though solid and apparently keeping its shape, will, if placed on a sloping board, very slowly commence to flow down the slope, the process being so slow that it takes hours, or even days, to give any observable result. In virtue of its " sham " viscosity—its power of cracking and healing incessantly by regelation—a sufficiently large and weighty mass of ice behaves in the same way. But it appears that the size of the mass is a very important condition. You can make a small upright figure, say four inches high, in soft wax, which will hold together and keep its form, but if you make a similarly shaped figure of the same material, ten feet high, it will bend and bulge and droop as a paraffin candle does in hot weather. The same importance attaches to actual bulk, height, or depth of the mass in regard to the flow of glacier ice, though it seems that the conditions of its flow or movement are not even yet thoroughly understood. Professor Heim holds that the weight of the ice is sufficient to account for its movement, and that a mass of lead corresponding to a glacier would in the same position move much as it does. The close fitting of the glacier to its bed, the fusion of tributary glaciers with a larger one, and the more rapid movement of the middle part of a glacier than of its sides (which are arrested and slowed down as is the water of a river by friction with the rocky sides of its bed) are due to the continual cracking and breaking with constant regelation of the ice at all points where it is strained or subject to tension. Regelation gives it, in the gross, the properties of a viscous body, such as pitch or soft sealing-wax—although ice is certainly, when small bits or crystals of it are examined, or even when we deal with a block of it weighing a ton, not a viscous body capable of being extended, that is, elongated or widened in shape, by pulling. It is not capable of being drawn out into strings or threads as are viscous bodies like pitch, sealing-wax and thick treacle! Under pressure, however, it does behave like a viscous body, and fragments or powder of ice can be squeezed in a mould into a solid coherent mass (as one

can squeeze and fuse powdered wax or amber when warm), owing to its property of "regelation," that is to say, of partial thawing under pressure and immediate re-freezing when the pressure is relaxed.

The thick, sticky "flows" or slowly moving streams of mud or watery clay, which one may see at the base of sea-side cliffs in many places, for instance, the Isle of Wight, are in important respects like small models of glaciers. One sees in them clearly enough that the middle part flows more quickly than the sides, and one sees the formation of crevasses by the "tearing" of the unequally moving mass. And the formation of what is called the veined structure of a glacier and of dirt bands on its surface are illustrated by similar appearances caused by the cracking and squeezing of the mud flow.

The squeezing to which glaciers are subject in their downward movement is often gigantic in amount. Glaciers from neighbouring rock valleys unite and form one slowly flowing river of ice without the breadth of the channel being proportionately increased. The glaciers which unite to form the great Gorner glacier above Zermatt have a width of ten miles, and soon after they have joined together the width is reduced to two miles, and farther on to one mile. The depth of the glacier is, of course, increased when its width is diminished. Swiss glaciers have been bored to a depth of 800 feet without reaching the bottom, and, small as they are compared with the great glaciers of the glacial age, it is calculated that they attain in places to a depth of 2,000 feet. There is enough solid ice in the great Gorner glacier to build three cities the size of London! There are about 1,500 glaciers in Switzerland, some of which, of course, unite with one another as they descend, and the total area they cover is over 1,000 square miles, with an average thickness difficult to estimate, but probably not over-estimated at 250 feet.

The colour of ice, like that of water, is blue, and of course the colour is deep and intense in proportion to the thickness of clear ice or water through which the light

passes. There is a great deal of persistent error about the blue colour of water. A good many people insist that it is due to the reflected blue colour of the sky. It is easy to prove that this is not so since the clear water of seas and lakes is seen to be blue when the sky is completely overcast. When the water is not very deep and the bottom is white, the colour is a very fine turquoise blue. But if the water is of such great depth that no light is reflected up from the bottom through the water, then the colour is a deep indigo. If the water has any yellow stain in it, from dead or living vegetable matter or from iron salts, the colour is green. There are two readily available exhibitions of the blue colour of water with which anyone may satisfy himself on the subject. The first is that of the tanks of some of the water-supplying companies, such as those to be seen from the railway near Caterham. These tanks are cube-like reservoirs, twenty feet deep. They are used to soften the water by precipitating the chalk dissolved in it, and the deposit of white chalk lines the bottom and sides of the tanks whilst the water itself becomes of crystalline purity. Even on the most cloudy days these tanks stand out in the scene as patches of brilliant cobalt blue. A simpler case is that of the large brilliantly white porcelain baths now provided in bathrooms. If the room is well lit from above by strong sunlight, and has a white wall, and the bath is well filled with good clear water, the latter appears strongly blue, any wave or rippling of the surface appearing as bands of bright blue. In this case the light is reflected to and fro by the sides of the bath, and an effect like that of the blue grotto of Capri is obtained. If the water should appear at all green, it is due to yellow-coloured impurity in the water, or in the porcelain, or in the colouring of the sides of the room.

Liquid oxygen (prepared by modern methods of producing extreme cold) is also blue. It is not surprising that solid water, which is what we look into in the great chasms in the clear ice of glaciers, should show this colour. Glaciers

often, however, appear bluish-green, especially near the surface, or when seen indistinctly at a distance. This is due to fine dust from the atmosphere, which falls continually on the mountain snow, and contains iron, which forms yellow-coloured rust in minute quantity. Some of the dust which falls on the snow of mountains and on the ocean (sinking there to the bottom) is of terrestrial origin, brought by the wind from great distances; but a great deal of it is dust (consisting of iron and other elements), which falls on the earth from interstellar space, and is called "meteoric dust." The particles are, in fact, minute "meteoric stones," or "falling stars," but so small and light that they do not become vaporized, or even red-hot, by friction with our atmosphere. They have been recognized in great quantity in the deposits on the floor of the great oceans, as well as on mountain snowfields, and it is estimated that a large number of tons of this "meteoric" material falls every year on to the surface of the earth, which must grow heavier in consequence.

The water which is formed by the melting in summer of the surface of a glacier above, and at the sides and below, forms a stream, which runs beneath the glacier and issues below the "snout." The snout frequently has the shape of an arch overhanging a cave, from which the stream issues. The water which forms by the melting of the upper surface of the glacier forms streams, which often grow to some size before they plunge into a crack or fissure in the ice, and find their way to the rocky bed below. They often wear the ice into a well-like shaft, some hundreds of feet deep, and carry stones down with them from the surface, which, lying on the rock at the bottom, are violently rocked and driven about by the falling water. Remarkable basin-like holes are thus worn out in the rock-bed of the glacier, which sometimes come into view when the glacier recedes, and exposes the rock which it formerly covered, as in the "Glacier Garden" at Lucerne. They are called "giants' cauldrons," and the ice-well into which the surface-water rushes is called a "moulin," or glacier mill.

By the retreat of a glacier we are able to see other results of its slow passage over the rocks, as, for instance, now at the lower end of the Mer de Glace of Chamonix. The rock is smoothed and polished, and the projecting harder parts are not sharp and angular, but have the form of rounded humps, compared to a carefully curled old-fashioned wig, and hence called "*roches moutonnées.*" When we come within three or four feet of such rocks we see that they are marked in a peculiar way by straight scratches of all lengths from half an inch upwards, and crossing one another at various angles, though one direction—that parallel to the valley—predominates. These scratches are caused by bits of harder stone which stick in the under surface of the ice, like emery powder on a lapidary's metal plate. They move slowly along with the ice, and so scratch the rock. Separate stones of hand-size may be picked up which have been scratched in this way, and their appearance is very distinctive. We know of no agency except that of moving ice by which loose stones and rocks can be made to scratch one another so as to give this special appearance. And accordingly, when we find such rocks in Wales and Scotland, and such stones in the "drift" and even below the Red Crag of Suffolk, we are led to the guess, which is confirmed by a great mass of additional evidence, that glaciers or great masses of moving ice existed formerly on the mountains of Wales and the plains of East Anglia.

Whilst the rocks which are covered, or were at one time covered, by the ice of a glacier are rounded, smoothed and scratched, the higher rocks which have never been submerged by the moving ice-mass stand out sharp and angular. They are continually broken and shattered by the action of frost, and shower down on to the glaciers their fragments, and sometimes immense masses of rock, which accumulate like a huge railway embankment at the sides of the glacier, or are slowly carried along by it as they rest on its surface (like a passenger on one of the new moving platforms or inclines), and so are deposited at the end

when the glacier melts away. These heaps of rock are called "moraines." Those at the sides of a glacier are called "lateral moraines," and the heap at the melting end or "snout" is a "terminal moraine." When two glaciers flow down neighbouring rock valleys which join in a common valley, as the two limbs of the letter Y join on the stem, the glaciers become pressed and fused together where they meet and form one glacier. The left lateral moraine of the right-hand valley (as you descend) joins the right lateral moraine of the left-hand valley, and the two form a "central moraine" on the mid-line of the slowly advancing combined mass of ice. The rock fragments on such a moraine are of all sizes, some as big as a small house, and piled up in some large glaciers to a breadth of a quarter of a mile. They give one a most vivid impression of the tremendous and incessant breaking down of the mountains. Often one may see such huge masses descend with a terrible roar from the heights above on to the glacier or an avalanche of smaller fragments amounting to hundreds of tons in weight, pouring down the precipitous rocks of the higher peaks. Sometimes when one looks from above on to the glacier a thousand or more feet below, the size of the rocky fragments of a central moraine is not appreciated. I once heard a newly arrived and inexperienced visitor at the Bel Alp exclaim as he looked down on to the great Aletsch glacier, "I suppose they have spread those cinders on the ice to make a path for us to walk on along the glacier." He had no notion that what, at that distance, he took for a cinder-path, consisted of huge pieces of rock mostly of the size of an omnibus!

A matter which is now greatly discussed among geologists and upon which different views are held, is the "grinding" or "excavating" action of glaciers upon the bed over which they slowly move. It is probable that their excavating activity has been exaggerated. They do not cut the first lines of a valley, but they constantly deepen the valleys along which they move. How much of this kind of excavation is due to the grinding action of the vast

weight of slowly moving ice and how much is due to the huge and violent rushing torrent of water which always underlies the ice and is hemmed in at the sides of the valley by it, seems to be differently estimated by American, Swiss, and English geologists.

LAUGHTER

THE ancients associated laughter with the New Year. I am not sure whether or no it is of good omen to begin the New Year with laughter. Omens are such tricky things that I have given up paying any attention to them. One would think it might be held to be unlucky to stumble on the doorstep as you set out from home, but the old omen-wizards, apparently from sheer love of contradiction, said, " Not at all! It is unlucky to stumble as you come into the house, and therefore it is lucky to stumble as you go out!"

What is laughter? It is a spasmodic movement of various muscles of the body, beginning with those which half close the eyes and those which draw backwards and upwards the sides of the mouth, and open it so as to expose the teeth, next affecting those of respiration so as to produce short rapidly succeeding expirations accompanied by sound (called " guffaws " when in excess), and then extending to the limbs, causing up and down movement of the half-closed fists and stamping of the feet, and ending in a rolling on the ground and various contortions of the body. Clapping the hands is not part of the laughter " process," but a separate, often involuntary, action which has the calling of attention to oneself as its explanation, just as slapping the ground or a table or one's thigh has. Laughter is spontaneous, that is to say, the movements are not designed or directed by the conscious will. But in mankind, in proportion as individuals are trained in self-control, it is more or less completely under command, and in spite of the most urgent tendency of the automatic mechanism to enter upon the progressive series of movements which we distinguish as (1) smile, (2) broad smile or grin, (3) laugh, (4) loud laughter, (5) paroxysms of uncontrolled laughter, a man or woman can prevent all indication

by muscular movement of a desire to laugh or even to smile. Usually laughter is excited by certain pleasurable emotions, and is to be regarded as an " expression " of such emotion just as certain movements and the flow of tears are an " expression " of the painful emotion of grief and physical suffering, and as other movements of the face and limbs are an " expression " of anger, others of " fear." The Greek gods of Olympus enjoyed " inextinguishable laughter."

It is interesting to see how far we can account for the strange movements of laughter as part of the inherited automatic mechanism of man. Why do we laugh? What is the advantage to the individual or the species of " laughing " ? Why do we " express " our pleasurable emotion, and why in this way? It is said that the outcast diminutive race of Ceylon known as the Veddas never laugh, and it has even been seriously but erroneously stated that the muscles which move the face in laughter, are wanting in them. A planter induced some of these people to camp in his " compound," or park, in order to learn something of their habits, language, and beliefs. One day he said to the chief man of the little tribe, " You Veddas never laugh. Why do you never laugh? " The little wild man replied, " It is true; we never laugh. What is there for us to laugh at? "—an answer almost terrible in its pathetic submission to a joyless life. For laughter is primarily, to all races and conditions of men, the accompaniment, the expression of the simple joy of life. It has acquired a variety of relations and significations in the course of the long development of conscious man—but primarily it is an expression of emotion, set going by the experience of the elementary joys of life—the light and heat of the sun, the approach of food, of love, of triumph.

Before we look further into the matter it is well to note some exceptional cases of the causation of laughter. The first of these is the excitation of laughter by a purely mechanical " stimulus " or action from the exterior, without any corresponding mental emotion of joy—namely by

" tickling," that is to say, by light rubbing or touching of the skin under the arms or at the side of the neck, or on the soles of the feet. Yet a certain readiness to respond is necessary on the part of the person who is " tickled," for, although an unwilling subject may be thus made to laugh, yet there are conditions of mind and of body in which " tickling " produces no response. I do not propose to discuss why it is that " tickling," or gentle friction of the skin produces laughter. It is probably one of those cases in which a mechanism of the living body is set to work, as a machine may be, by directly causing the final movement (say the turning of a wheel), for the production of which a special train of apparatus, to be started by the letting loose of a spring or the turning of a steam-cock, is provided, and in ordinary circumstance is the regular mode in which the working of the mechanism is started. The apparatus of laughter is when due to " tickling " set at work by a short cut to the nerves and related muscles without recourse to the normal emotional steam-cock.

Then we have laughter which is purely due to imitation and suggestion. People laugh because others are laughing, without knowing why. This throws a good deal of light on the significance of laughter. It is essentially a social appeal and response. Only in rare cases do people laugh when they are alone. Under conditions which in the presence of others would cause them to laugh they only " chuckle " or smile, and may, though ready to burst into laughter, not even exhibit its minor expressions when alone. On the other hand, some sane people have the habit of laughing aloud when alone, and there is a recognised form of idiocy which is accompanied by incessant laughter, ceasing only with sleep. Then there is that peculiar condition of laughter which is called " giggling," which is laughter asserting itself in spite of efforts made to restrain it, and frequently only because the occasion is one when the " giggler " is especially anxious not to laugh. This kind of " inverted suggestion," as in the case where an individual " blurts out " the very word or phrase which he is anxious

not to use, is obviously not primitive, but connected with the long training and drilling of mankind into approved "behaviour" by "taboos" and restrictive injunctions. Efforts to behave correctly, by causing anxiety and mental disturbance in excitable or so-called "nervous" subjects, lead to an overmastering impulse to do the very thing which must not be done.

It seems that laughter has its origin far back in the animal ancestry of man, and is essentially an expression to others of the joy and exhilaration felt by the laugher. It is an appeal through the eye and ear for sympathy and comradeship in enjoyment. Its use to social animals is in the binding together of the members of a group or society in common feeling and action. Many monkeys laugh, some of them grinning so as to show the teeth, partly opening the mouth and making sounds by spasmodic breathing, identical with those made by man. I have seen and heard the chimpanzees at the Zoological Gardens laugh like children at the approach of their friend and my friend, the distinguished naturalist Mr. George Boulenger, F.R.S., recognizing him among the crowd in front of their cage when he was still far off. And I have often made chimpanzees laugh—"roar with laughter," and roll over in excitement—by tickling them under the arms. The saying of Aristotle (inscribed over the curtain of the Palais Royal Theatre in Paris) that "laughter is better than tears, because laughter is the speciality of man," is not true. Not only do the higher apes and some of the smaller monkeys laugh, but dogs also laugh, although they do not make sounds whilst indulging in "spasms of laughter." But their distant cousin, the hyena, does laugh aloud, and its laughter agrees with that of the dog and with the laughter of children and grown men in simpler moods in that it is caused by the pleasurable emotion set up by the imminent gratification of a healthy desire. The hyena laughs, the dog grins and bounds, the child laughs and jumps for joy at the approach of something good to eat. But it is a curious fact that the whole attitude is changed when the

food is within reach, and the serious business of consuming it has commenced! Nor, indeed, is the satisfaction which is felt after the gratification of appetite accompanied by laughter. It seems that the display of the teeth by drawing back the corners of the mouth, which is called a "grin," and is associated in many dogs with short, sharp, demonstrative barks, and in mankind with the cackle we call a "laugh," is a retention, a survival, of the playful, good-natured movement of gently biting or pulling a companion with the teeth used by our animal ancestors to draw attention to their joy and to communicate it to others. Gradually it has lost the actual character of a friendly bite; the fore-feet or hands pull instead of the teeth; the sound emitted has become further differentiated from other sounds made by the animal. But the movement for the display of the teeth, though no longer needed as a part of the act of gripping, remains as an understood and universal indication of joy and kindly feeling. So universal is it that this friendly display of the teeth under the name "smile" is attributed to Nature, to Fortune, and to deities by all races of men when those powers seem to favour them.

Laughter is, then, in its essence and origin, a communication or expression to others of the joyous mood of the laugher. There are many and strangely varied occasions when laughter seizes on man, and it is interesting to see how far they can be explained by this conception of the primary and essential nature of the laugh, for many of them seem at first sight remote from it. There is, first of all, the laughter of revivification and escape from death or danger. After railway accidents, earthquakes, and such terrible occurrences, those who have been in great danger often burst into laughter. The nervous balance has been upset by the shock (we call them "shocking accidents"), and the emotional joy of escape, the joy of recovered life, asserts itself in what appears to the onlooker to be an unseemly, an unfeeling laugh. It is recorded that one of the entombed French coal miners, who two

years ago were imprisoned without food or light for twenty days a thousand feet below in the bowels of the earth, burst into a ghastly laugh when he was rescued and brought to the upper air once more. The Greeks and Romans in some of their festal ceremonies made the priest or actor who represented dead nature returning to life in the spring, burst into a laugh—a ceremonial or "ritual" laugh. Our poets speak of the smiles, and even of the laughter of spring, and that is why laughter is appropriate to New Year's Day. It is the laughter of escape from the death of winter and of return to life, for the true and old-established New Year's Day was not in mid-winter, but a quarter of a year later, when buds and flowers are bursting into life. It is recorded by ancient writers that the "ritual laugh" was enforced by the Sardinians and others who habitually killed their old people (their parents), upon their victims. They smiled and laughed as part of the ceremony, the executioners also smiling. The old people were supposed to laugh with joy at the revivification which was in store for them in a future state. So, too, the Hindoo widows used to laugh when seated on the funeral pyre ready to be burnt. So, too, is explained (by Reinach) the laughter of Joan of Arc when she made her abjuration in front of the faggots which were to burn her to death. Her laugh was caused by the thought of her escape from persecution and of the joyful resurrection soon to come. It was not an indication that she was not serious, and that her abjuration of witchcraft was a farce, as her enemies asserted.

More difficult to explain is the laughter excited by scenes or narrations which we call ludicrous, funny, grotesque, comic; and still more so the derisive and contemptuous laugh. Caricature or burlesque of well-known men is a favourite method of producing laughter among savages as well as civilized peoples. Why do we laugh when a man on the stage searches everywhere for his hat, which is all the time on his head? Why do we laugh when a pompous gentleman slips on a piece of orange-peel

and falls to the ground, or when one buffoon unexpectedly hits another on the head, and, before he has had time to recover, with equal unexpectedness hooks his legs with a stick and brings him heavily to the ground? Why did we laugh at the adventures of Mr. Penley in "Charley's Aunt"? In all of these "ludicrous" affairs there is an element of surprise, a slight shock which puts us off our mental balance, and the subsequent laughter, when we realize either that no serious harm has been done or that the whole thing is make-believe, seems to partake of the character of the "laugh of escape." It is caused by a sense of relief when we recognize that the disaster is not real. We laugh at the "unreal" when we should be filled with horror and grief were we assured that there was real pain and cruelty going on in front of us. The laughter caused by grotesque mimicry or caricature of pompous or solemn individuals seems to arise from the same (more or less unconscious) working of the mind as that caused by some unexpected neglect of those social "taboos" or laws of behaviour which we call modesty, decency, and propriety. They either cause indignation and resentment in the on-looker at the neglect of respect for the taboo, or, on the contrary, the natural man, long oppressed by pomposity or by the fetters of propriety imposed by society, suddenly feels a joyous sense of escape from his bonds, and bursts into laughter—the laughter of a return to vitality and nature—which is enormously encouraged and developed into "roars of merriment" by the sympathy of others around him who are experiencing the same emotion and expressing it in the same way.

The laugh of derision and contempt and the laugh of exultation and triumph are of a different character. I cannot now discuss them further than to say that they are either genuine or pretended assertions of joy in one's own superior vitality or other superiority. The "sardonic smile" and "sardonic laughter" have been supposed by some learned men to refer to the smiles of the ancient Sardinians when stoning their aged parents. But they

have no more to do with Sardinians than they have with sardines or sardonyx. The word " sardonic " is related to a Greek word which means " to snarl," and a sardonic grin is merely a snarl. In it the teeth are shown with malicious intent, and not as they are in the benevolent appeal of true laughter. Mrs. Grote, the wife of the great historian (who was herself declared by a French wit to furnish the explanation of the word " grotesque "), wrote of " Owen's sugar-of-lead smile "—referring to the great naturalist, Richard Owen. There was no malice in the description, for he had, as some others have, a very sweet smile, accompanied by a strangely grave and disapproving glare in his large blue prominent eyes. It was only apparently sugar of lead; really, it was sugar of milk—the milk of human kindness.

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